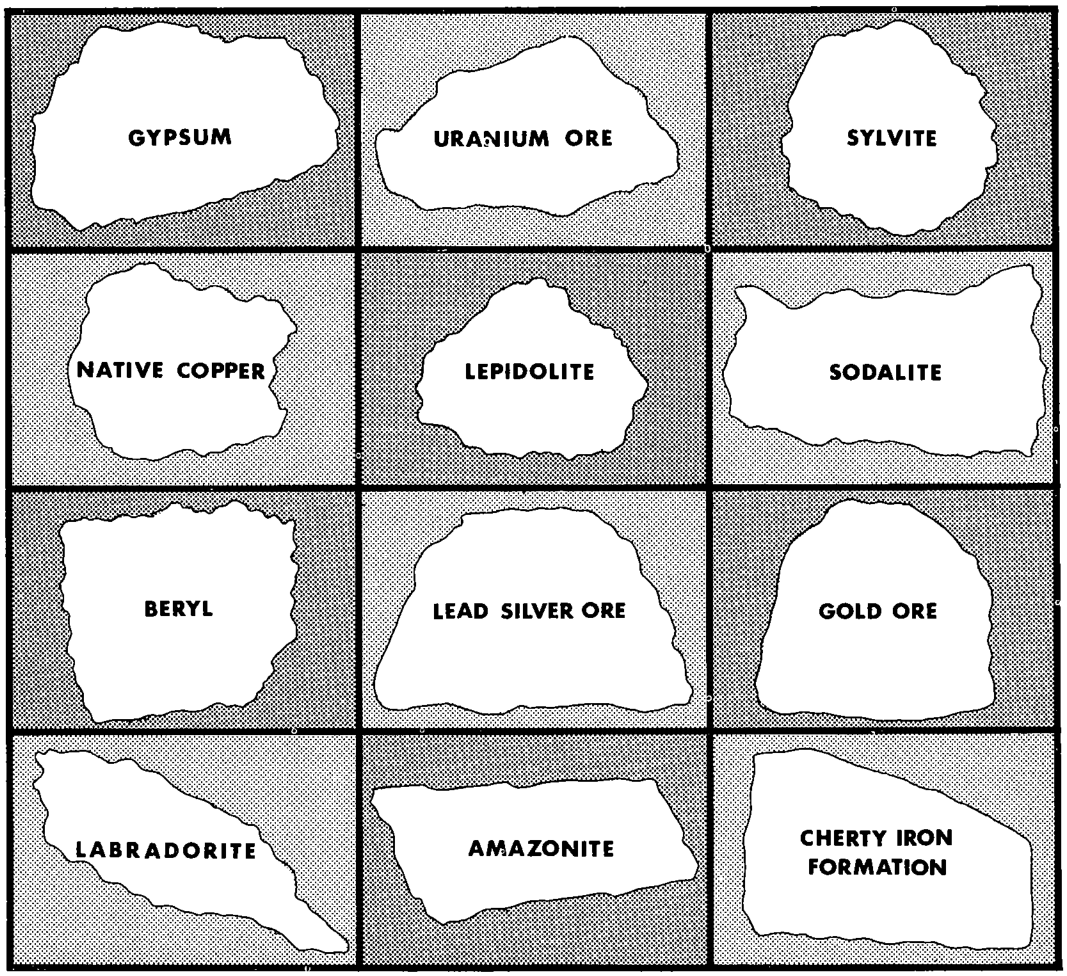
CANADIAN MINERALS YEARBOOK 1972



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Mineral Report 22

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Foreword

This issue of the Canadian Minerals Yearbook is a report of developments in the industry for 1972. The 54 chapters dealing with specific commodities, were issued in advance under the title Preprints, Canadian Minerals Yearbook 1972 to provide information as soon as possible to interested persons. The General Review, written specifically for the Yearbook each year, deals with the overall position of the industry in its national and international perspective; it is supported by 73 statistical tables not readily available from other sources. The Index to Companies provides full and accurate company names and a complete cross reference to corporate activities in the Canadian industry, supported again by pocket map 900A, Principal Mineral Areas of Canada.

The Yearbook is the permanent official record of the growth of the mineral industry in Canada and is preceded by similar reports under various titles dating back to 1886. Those wishing to refer to previous reports should consult departmental catalogues, available in most libraries.

The basic statistics on Canadian production, trade and consumption were collected by Statistics Canada, unless otherwise stated. Company data were obtained directly from company officials or corporate annual reports by the authors. Market quotations were mainly from standard marketing reports.

The Department of Energy, Mines and Resources is indebted to all who contributed the information necessary to compile this report.

October 1973

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Graphics and Cover: N. Sabolotny

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Readers wishing more recent information than that contained in the present volume should obtain the 1973 series of preprints: complete set available from Information Canada, Ottawa, $5. Individual copies are available from the Distribution Office, Mineral Development Sector, Department of Energy, Mines and Resources, at 25¢ each.

Frontispiece:

A face-on view of two miners each operating a jackleg drill at Sherritt Gordon Mines Limited, Lynn Lake, Manitoba. (George Hunter photo).

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General Review

The Canadian economy 1972*

The Canadian economy in 1972 continued the cyclical expansion which began late in 1970. During 1972, more jobs were created than in 1971 coupled with a substantial rise in real income per person. The first two quarters of 1972 saw an uninterrupted expansion in the economy, but during the third quarter there were some temporary factors which reduced the expansion pace. These included unfavourable weather conditions which affected farm output and employment in central Canada and a number of labour disputes resulting in strikes in the mining and forest industries thus seriously affecting Canadian production and exports.

Production. In 1972, the value of Canada's Gross National Product (GNP) at current prices reached 103.4 billion compared with 93.4 billion during 1971. This was an increase of 10.7 per cent over 1971. The growth in GNP from 1955 to 1972 and the comparison between GNP in current and in constant dollars is shown in Figure 1. In terms of constant dollars the Canadian economy during 1972 continued the 1971 growth pattern, an expansion at the rate of about 5.8 per cent per annum.

During 1972, the GNP in constant dollars per head rose to about $3,285 an increase of 4.52 per cent over 1971.

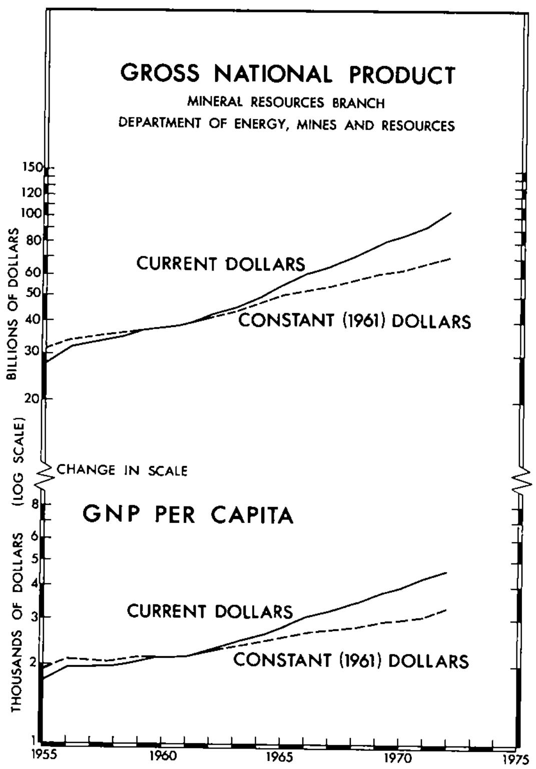


Figure 1

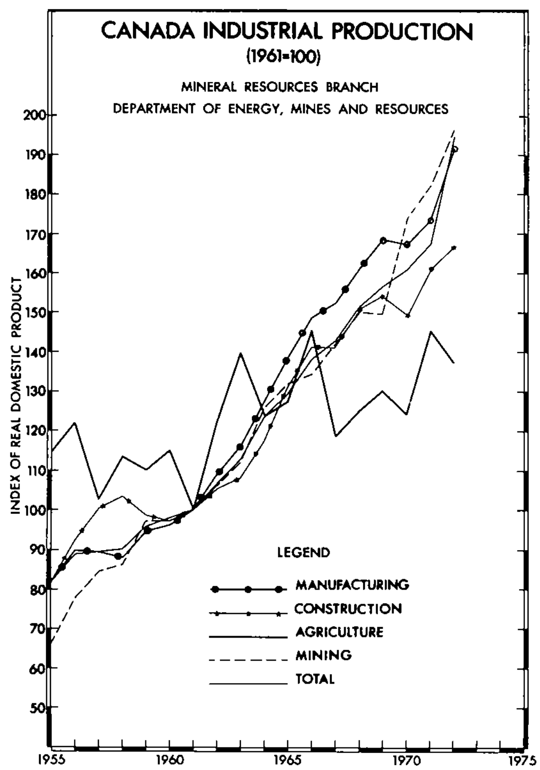


Figure 2

* This section and the mineral economy section of the General Review were written by S.P. Malhotra of the Mineral Economic Research Division.

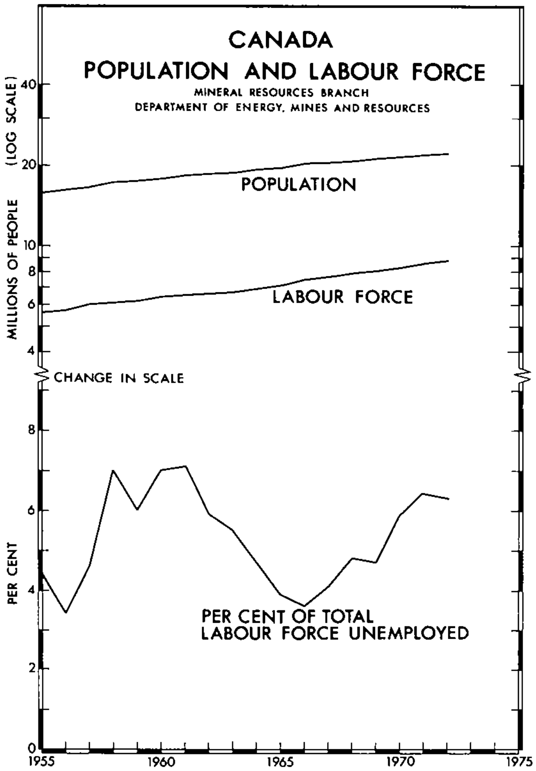


Figure 3

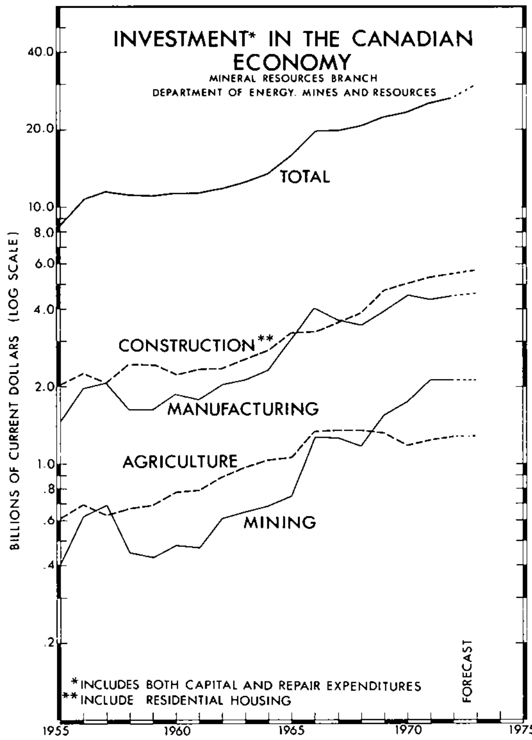


Figure 4

Total output as measured by the index of real domestic production (RDP) rose by 5.3 per cent to 184.3 during 1972. In the first quarter of 1973, RDP increased very marginally as gains in most sectors were offset by decreases in agriculture, forestry, fishing and transportation sectors. RDP increased by 1.8 per cent in the second quarter and only 0.2 in the third quarter. The small increase in the third quarter was mainly due to labour disputes in the mining sector which cut output by 4 per cent and indirectly affected the transportation sector. Most of the industrial sectors recorded increased production during the fourth quarter. Figure 2 illustrates the trends in the index of real domestic product from 1955 to 1972.

Prices. During 1972 virtually every major price series showed an acceleration in the rate of price increase. The consumer price index for 1972 at 139.8 (1961 = 100) had risen 4.8 per cent compared with 2.9 per cent in 1971. The increase in consumer prices during 1972 was mainly attributable to the steep rise in food prices. Retail food prices in 1972 rose 7.6 per cent compared to 1.1 per cent in 1971. This sharp acceleration in food prices primarily reflected supply difficulties in several primary markets.

Employment. The year 1972 was slightly better than 1971 for the Canadian economy. During 1972 the number of people employed in Canada increased by 250,000. This was 3.1 per cent higher than the previous year. This rate of increase was the strongest recorded since 1969 when the rate of employment growth was 3.2 per cent. The increase in employment in 1972 was, however, offset by a sharp increase in the total labour force by 260,000 or 3 per cent. As a result, the unemployment rate in 1972 declined only marginally to 6.3 per cent from 6.4 per cent in 1971. The trends in population and other related series since 1955 are presented in Figure 3.

Capital and repair expenditure. Total capital and repair expenditure on plant, machinery, equipment and construction in Canada during 1972, at current prices, was $28.2 billion. This was almost $1.9 billion or 7.2 per cent higher than in 1971. There was a substantial increase in spending on machinery and

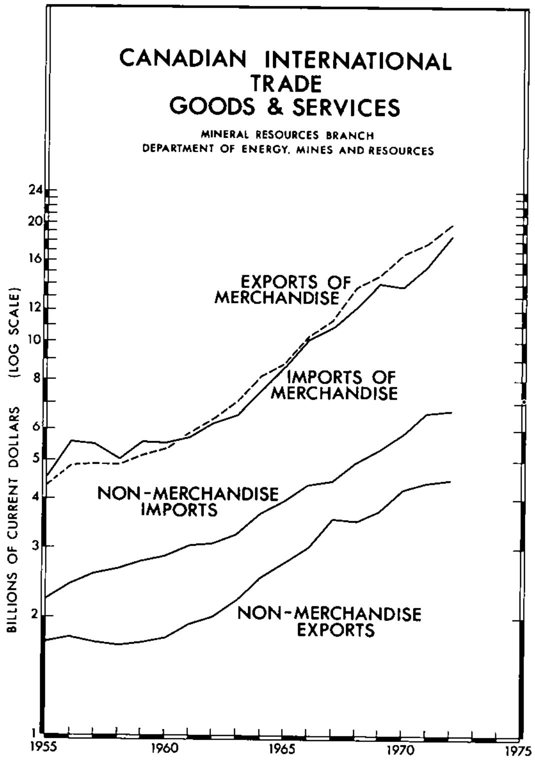


Figure 5

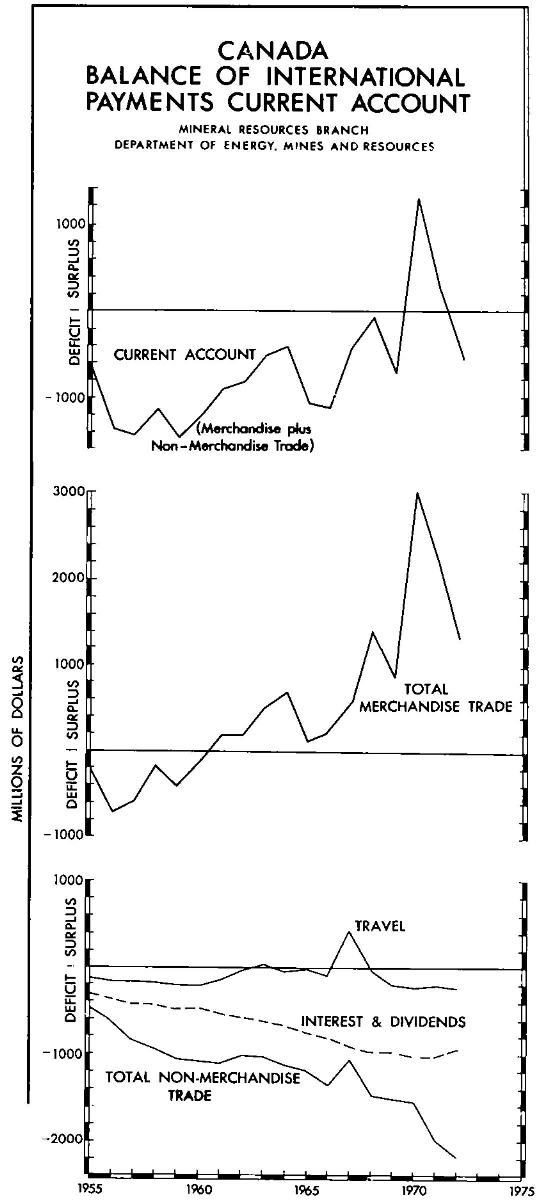


Figure 6

equipment but non-residential construction showed only a little growth. Figure 4 shows the trends in the total capital and repair expenditures in major Canadian industrial sectors from 1955 to 1972 including a forecast for 1973. The capital and repair expenditure program forecast for 1973 is $30.5 billion, a rise of 8.2 per cent over 1972. This represents a moderate acceleration of investment expenditure in 1972 over 1971.

Balance of international payments. Canada's current account was in deficit by $584 million in 1972. This represents a loss of nearly $1 billion from the 1971 surplus of $397 million and about $1.6 billion lower than the recorded surplus in 1970. The decline in 1972 current account is entirely accounted for by a fall in the merchandise trade surplus to $1.4 billion from $2.3 billion in 1971. Trends in the merchandise and non-merchandise trade and current account from 1955 to 1972 are illustrated in Figures 5 and 6. During 1972, merchandise exports rose by about 12 per cent, but this was not sufficient to keep pace in the merchandise imports, which increased by 20 per cent.

Figure 7 illustrates the behaviour of Net Capital Movement in the Canadian Balance of International Payments from 1955 to 1972. As can be seen, the net capital inflows in 1972 amounted to $800 million, a

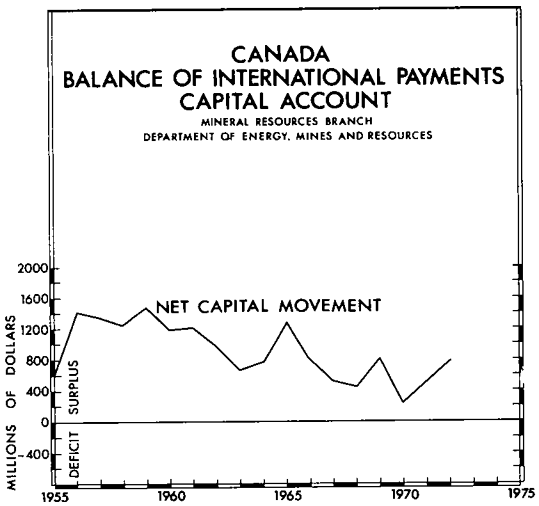


Figure 7

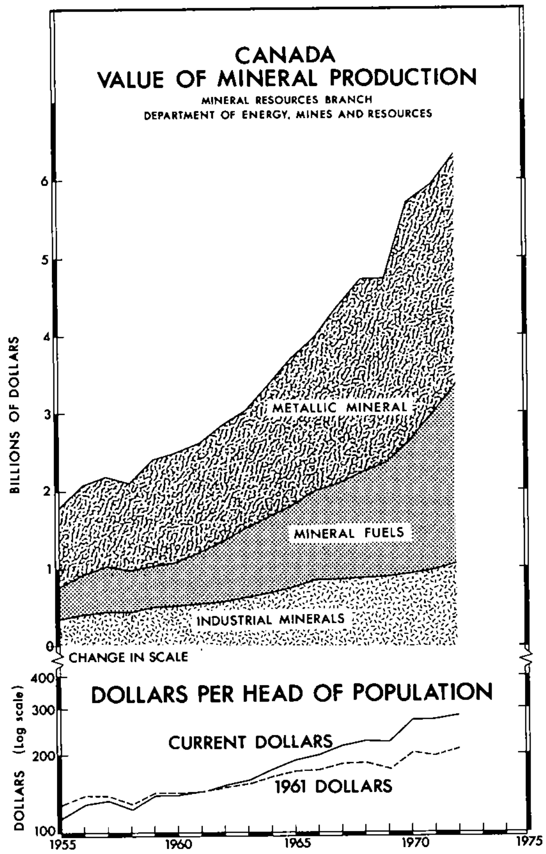


Figure 8

substantial increase over the 1972 figure of $380 million. Inflows of long-term capital in 1972 were $1.8 billion compared with $394 million in 1971, the latter being the lowest level since 1955. The large increase was due mainly to increased provincial borrowing abroad as a result of tighter credit conditions in Canada than abroad during the first half of 1972. Inflows subsequently tapered off as interest rate differentials moved against foreign source of funds.

The mineral economy

Mineral production. The value of Canadian mineral production, including oil and natural gas, and covering mining, smelting and refining activities, was over 6.4 billion in 1972, up 449 million from the revised total for 1971. Since 1955, the Canadian mineral output has grown more than three and one half times, at an annual rate of 7.8 per cent.

Figure 8 illustrates growth of three major sectors of the Canadian mineral industry from 1955 to 1972. As can be seen all three made gains in 1972, especially the mineral fuels, the output of which rose by $346 thousand to 2,355 million – a rise of 17 per cent over 1971. In terms of current dollar value per head of Canadian mineral production, the past trend continued. It rose to $293.5 in 1972 from $273.2 in 1971.

Figure 9 shows mineral production by commodity and province for 1972 in percentage. As in the past year, petroleum was the dominant mineral commodity in terms of value of output in 1972, with 24.5 per cent of the total. In terms of provincial mineral production, Alberta made the largest single contribution of 30.5 per cent of the total, followed by Ontario which contributed 24.0 per cent.

Mineral trade. Canada exported $5.5 billion worth of crude and fabricated minerals during 1972, with the United States buying the bulk of mineral exports, 64 per cent, while Britain took 9.7 per cent, Japan 9.1 per cent and the European Economic Community*(EEC) 7 per cent. Figure 10 illustrates the declining share of mineral exports to Britain and the EEC in the last decade and the fact that in the case of Japan, they have increased in value and volume. Canadian mineral exports to the United States were 4.7 per cent higher in 1972 than in 1971.

* It includes only six old members of the present EEC, i.e., Belgium, France, Italy, Luxembourg, Netherlands and West Germany.

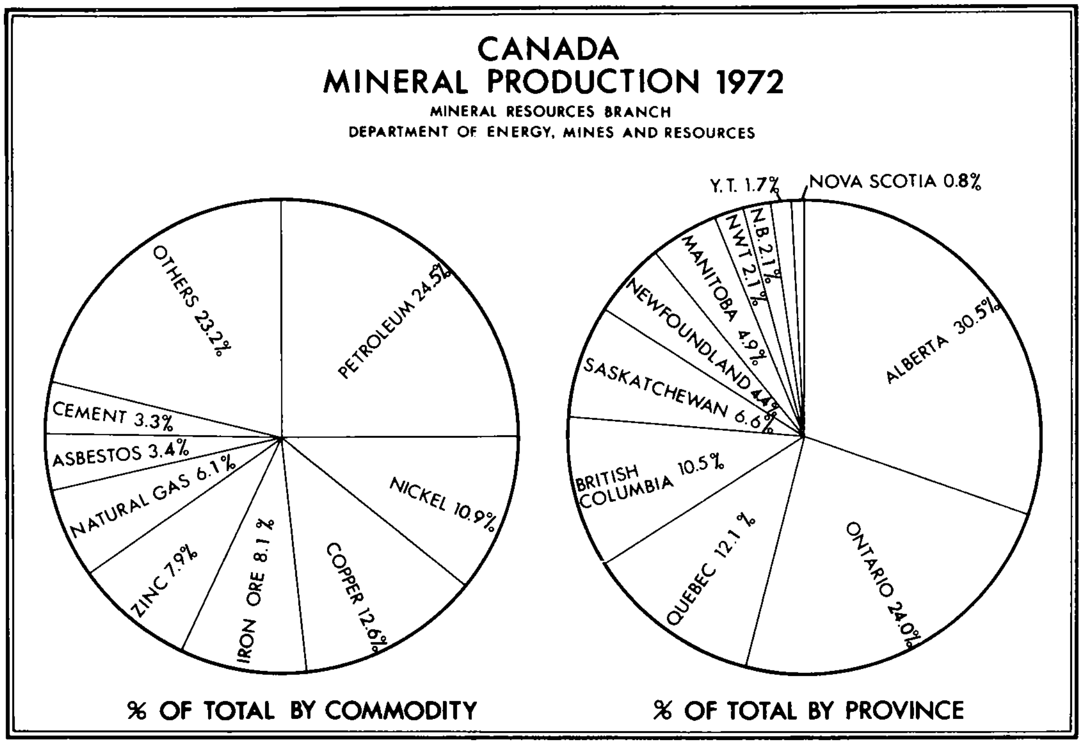


Figure 9

Trends in Canadian mineral trade since 1964 are illustrated in Figure 11. From 1964 to 1972, the value of exports, including both crude and fabricated mineral products, went up from $2,584.2 million to $5,499.8 million similarly, the value of imports during this period rose from $1,515.4 million to $2,813.6 million. This was a 9.9 per cent per annum growth rate for mineral exports and a 8.1 per cent for mineral imports between 1964 and 1972. In terms of share of minerals exports, including both crude and fabricated products, as a percentage of total Canadian trade, it has been falling slowly during 1964-1972. It fell from an average of 30.5 per cent to 28.2 per cent. During this period, mineral fabricated products, which were running at an average of about 14 per cent, fell to 11.4 per cent in 1972, while crude minerals moved up from an average of 16.6 per cent to 16.8 per cent.

Mineral prices. The trends in general wholesale price indices of mineral products since 1951 are shown in Figure 12. The wholesale price index for iron products, which has been the highest mineral industry price index in recent years, increased only 2.7 per cent in 1972, while the nonferrous metals products index was 262.9, up 1.1 per cent from 1971, and nonmetallic mineral products at 233.6 showed a price increase of less than 3.5 per cent. The price behaviour of nonferrous metals during 1972 was mixed. For aluminum ingot, actual prices have remained low because of over-supply. The United States producers' price for copper rose to 52 cents a pound early in the year, but dropped to 50 cents in midyear and remained there. Canadian producers' price followed a similar trend and in December it was set at 50.3 cents a pound to compensate for the change in the exchange rate between the Canadian and United States dollar. Zinc prices have improved from the very low levels of previous years to reach approximately 20 cents a pound during 1972. At midyear 1972 the Canadian lead price stood at 16 cents a pound, an improvement on the 13.5 cents a pound at the beginning of the year. However, the price declined in October and at the end of 1972 the Canadian lead price was 15 cents a pound.

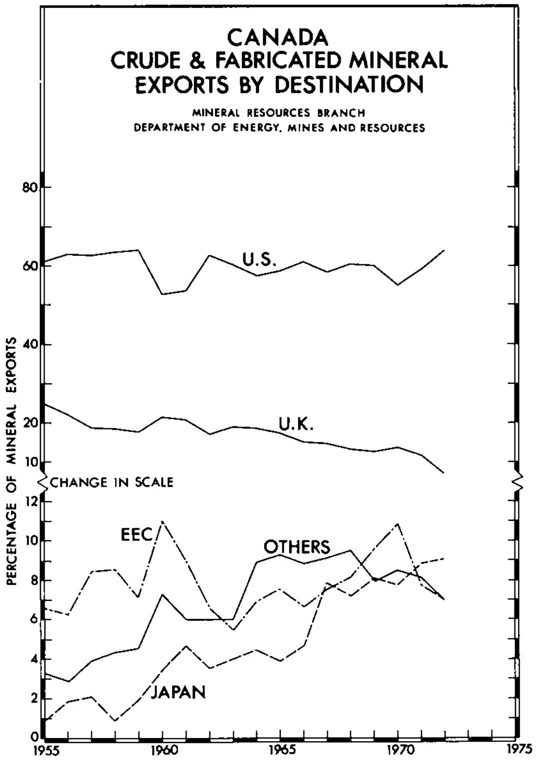


Figure 10

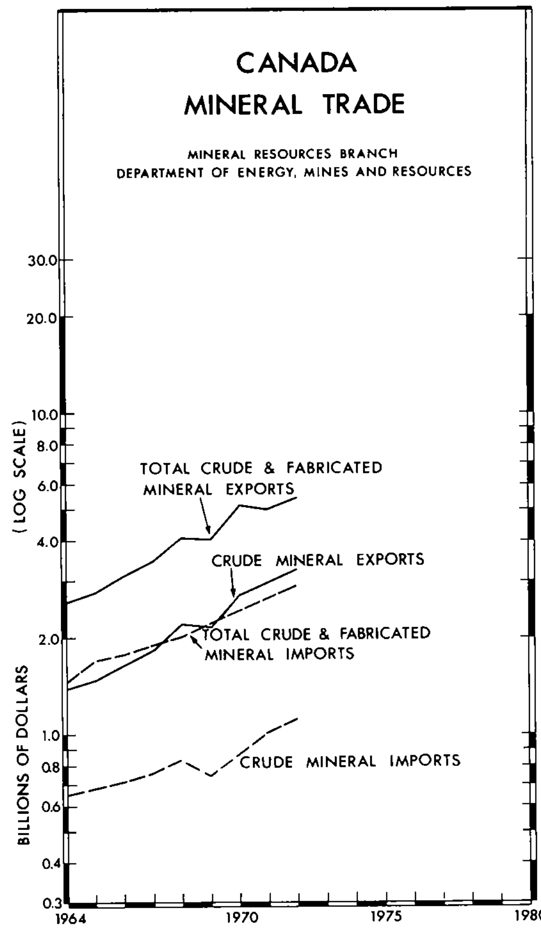


Figure 11

Investments in durable physical assets. For many years the Canadian mineral industry, including mining and mineral manufacturing has been among the most capital-using industries in the Canadian economy. In 1951 it used \$599 million and occupied third position among Canadian industries after manufacturing, and agriculture and fishing, but by 1972 it had jumped to first place at \$3.5 billion followed by manufacturing (excluding mineral manufacturing) at \$3.2 billion. This represented a growth rate of gross capital new investment (capital as well as repair) in the Canadian mineral industry of 8.4 per cent per annum, mining being 11 per cent – the highest among industrial sectors – and mineral-based manufacturing 5.9 per cent, compared with construction at 7.6 per cent, manufacturing 6.3 per cent, forestry 3.1 per cent, agriculture and fishing 3.1 per cent, and the total of all Canadian industries at 6.6 per cent.

In terms of percentage of total new investment in the Canadian economy, the mineral industry also leads. In 1951 its share was 8.9 per cent which by 1972 had jumped to 12.8 per cent. This compares with manufacturing (excluding mineral manufacturing) which went down from 12.4 to 11.7 per cent, and agriculture and fishing, from 10.5 to 5.1 per cent in the same period.

Trends in investment in durable physical assets, including both capital and repair expenditures, for six major mineral sectors from 1951 and 1972 and forecasts for 1973 are illustrated in Figures 13 and 14.

Foreign ownership and control. Between 1945 and 1969 the book value of U.S. long-term investment in Canada rose from \$5.4 billion to \$34.8 billion (Table

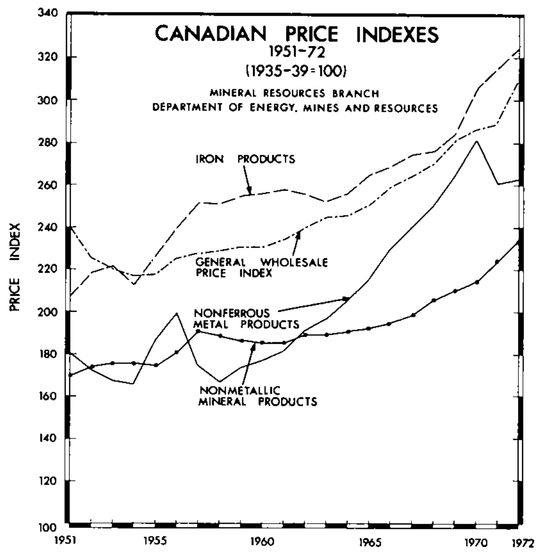


Figure 12

1) with direct investment increasing from under $2 billion to about $18 billion. Approximately half of this increase was for the development of Canada's natural resources. U.S. investment accounted for 74.2 per cent of total foreign capital invested in Canada up to the year 1969.

At the end of 1970 assets of foreign controlled* corporations rose to $48.8 billion, representing 35.7 per cent of assets of all non-financial corporations in Canada compared with 35.1 per cent in 1969.

Capital expenditure and takeovers in several mineral and energy industries were major factors contributing to the rise in the value of assets under foreign control during 1970. There were large investments in new plant and machinery in the oil and gas industries where exploration was dominant in northern Canada following oil and gas strikes in Alaska and Mackenzie River Delta. Capital investment was substantial in the primary metals industry, besides significant takeovers in the nonmetallic mineral products industries during 1970.

Table 1 shows the amount and percentage distribution of assets by control and major mineral sectors during 1970. As can be seen, assets of all mineral sectors in Canada, with the exception of primary metals, were owned by foreign residents in 1970. At the end of 1970, $5.8 billion or 100 per cent of total capital employed in the petroleum and coal products was controlled by non-residents. Similarly, 82.5 per cent of mineral fuels, 61.1 per cent of metal mines and 63.1 per cent of nonmetallics capital employed at the end of 1970 was controlled by non-residents. Substan-

* A company is considered to be foreign controlled if 50 per cent or more of its voting rights are known to be held outside Canada and/or by one or more Canadian companies which are, in turn, foreign controlled.

Table 1. Canada's balance of international indebtedness, by area, selected year-ends, 1926-69

	United States (1,2)	United Kingdom (1,2)	All Other Countries (1,2,3)	Short-term (n.i.e.)	Total
			(billions of dollars)		
Gross liabilities:					
1926	3.5	2.7	0.2	..	6.4(1)
1930	4.9	2.9	0.2	..	8.0(1)
1933	4.7	2.8	0.2	..	7.7(1)
1939	4.5	2.6	0.3	..	7.4(1)
1945	5.4	1.8	0.4	0.6	8.2
1949	6.4	1.8	0.5	0.6	9.3
1954	10.3	2.3	0.9	0.4	14.0
1959	17.0	3.4	2.1	1.4	23.8
1964	23.1	3.6	2.8	3.2	32.8
1969p	34.8	4.5	5.4	2.3	46.9

(1) Excludes short-term receivables and payables n.i.e.
(2) Excludes net official monetary assets.
(3) Includes international investment agencies.
Source: Canada's International Investment Position, 1926 to 1967, Statistics Canada.
p Preliminary

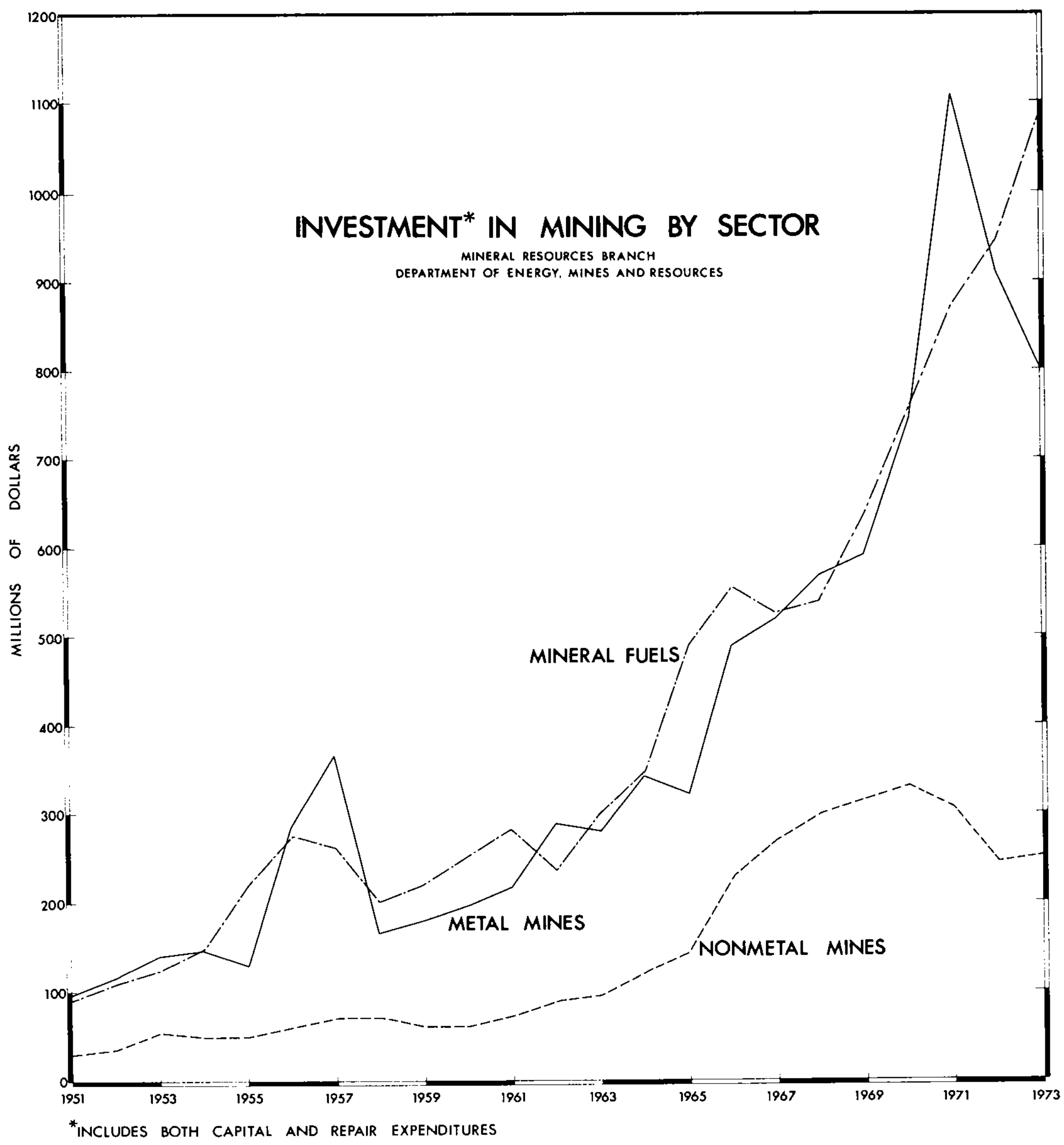


Figure 13

tial amounts of these investments were owned by the U.S. residents. Both U.S. and other foreign control have been increasing since 1954.

Industrial fatalities. Trends in industrial fatalities since 1961 for various industrial groups are shown in Table 2. Industrial fatalities per thousand workers were the highest in the mining industry compared with other industrial groups during 1961-71. Mining fatalities, during this period, averaged 1.48 per thousand workers compared with forestry 1.35, fishing and trapping 1.19 and manufacturing industries only 0.12. In 1971, mining fatalities declined to a rate of 0.95 per thousand workers compared with 0.96 in 1970.

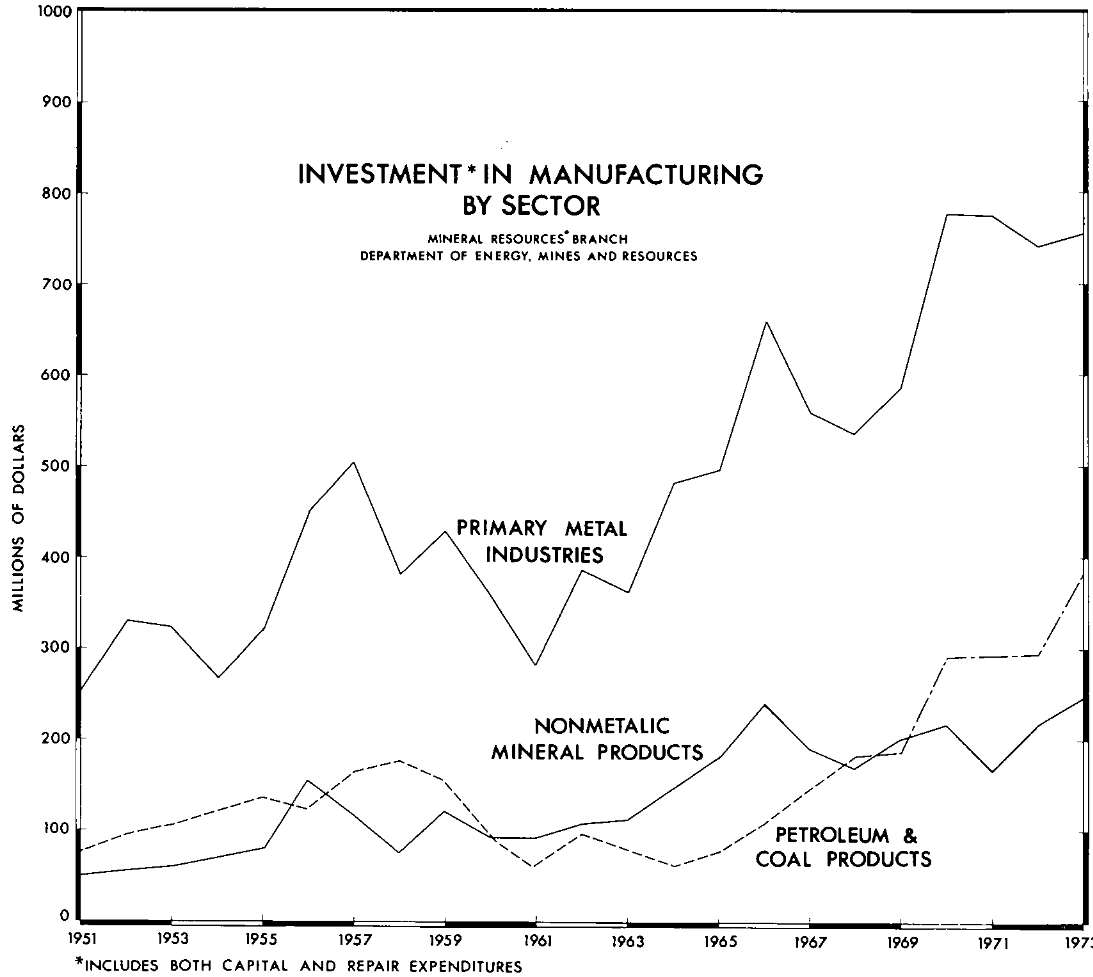


Figure 14

This was a slightly lower fatality rate than experienced by forestry and trapping during 1971, at 1.07 per thousand workers.

Return on invested capital. Figure 15 compares the average 1962-70 rate of return on invested capital percentage ratios of various sectors in the Canadian mineral industry with total of all Canadian industries. Among various sectors presented, metal mines show the highest average rate of return at 13.0 per cent, while mineral fuels the lowest at 5.6 per cent compared with the total of all Canadian industries at 10.2 per cent.

During 1962-1969, for the mining industry, the rate of return moved upward from 1962 to 1965, when it peaked at 11.6 per cent. After 1965 the rate started declining until in 1969 (a strike year) it finally dropped to a low of 9.2 per cent. In mineral-based manufacturing, the rate of return on capital employed followed a similar pattern. It moved upward until 1965 when it reached 10.3; then it started declining and registered 7.8 for 1970.

Employment. Currently, the Canadian mineral industry employs around 301,000 people; 120,000 working in the mining sector, and 181,000 in mineral

Table 2. Industrial Fatalities Per Thousand Workers by Main Industry Groups (1961, 1965 and 1969–1971)

	1961	1965	1969	1970	1971p
Agriculture	0.10	0.08	0.06	0.03	0.04
Forestry	1.15	1.40	1.10	1.11	1.07
Fishing[1]	2.22	1.74	0.86	1.05	0.36
Mining[2]	1.69	1.31	1.40	0.96	0.05
Manufacturing	0.12	0.14	0.11	0.08	0.08
Construction	0.63	0.60	0.49	0.36	0.41
Transportation[3]	0.33	0.47	0.30	0.20	0.25
Trade	0.05	0.06	0.05	0.04	0.05
Finance[4]	0.01	0.01	0.01	0.01	0.08
Service[5]	0.02	0.03	0.03	0.02	0.02
Public administration	0.19	0.13	0.14	0.13	0.13
Total	0.19	0.19	0.14	0.11[6]	0.12

[1] Includes trapping, hunting. [2] Includes quarrying and oil wells. [3] Includes storage, communication, electric power and water utilities. [4] Includes insurance and real estate. [5] Includes community. business and personal service. [6]Includes seven fatalities in unspecified industries.
pPreliminary.

manufacturing. Mining, a capital-intensive industry, employs about 1.3 per cent of the total Canadian labour force, while mineral-based manufacturing employs 2.1 per cent.

Annual changes in employment by industry from 1969-72 are presented in Table 3. As can be seen, the larger share of the employment gains in 1972 occurred in the service producing industries where the number of jobs increased by 218,000 or 4.3 per cent. During 1972, employment in most goods producing industries, with the exception of manufacturing and construction, declined, mining employment declined by 5,000 workers whereas agriculture declined by 29,000 people.

Tax incentives to the mineral industry*

Although mineral industry enterprises are subject to federal income tax, there are certain benefits granted to such enterprises under the Income Tax Act which serve as incentives to exploration and development of minerals, and to further processing of minerals.

Certain modifications were made in the tax incentives to the mineral industry in the amended Income Tax Act which became effective on January 1, 1972.

Under the provisions of the amended Act, the exemption from income tax for the first three years of operation of new mining ventures, which first came into effect in 1936, will terminate at the end of 1973. However, initial capital expenditures in a new mining operation on buildings, machinery and equipment, and certain community and transportation facilities may be deducted as rapidly as income will permit. Consequently, new mining ventures will not be liable for federal income tax until these initial capital expenditures have been recovered. In the case of a major expansion of an existing mine, capital expenditures on buildings, and machinery and equipment also may be deducted immediately.

The operators of oil or gas wells or mines have

* This section was prepared by E.C. Hodgson of Resource Development Division.

Table 3. Amount and Percentage Distribution of Assets by Control of Non-Resident Ownership by Major Mineral Sectors, 1970

Mineral Sectors	Non-Resident Owned Assets	%	Canadian Assets	%	Total Assets	%
			(billions of dollars)			
Metal mines	4.1	61.1	2.6	38.9	6.7	100
Other mines	1.6	57.1	1.2	42.9	2.8	100
Mineral fuels	4.7	82.5	1.0	17.5	5.7	100
Total mining	10.4	68.4	4.8	31.6	15.2	100
Primary metal	2.0	43.3	2.6	56.7	4.6	100
Nonmetallics	1.2	63.1	0.7	36.9	1.9	100
Petroleum and coal products	5.8	100.0	–	–	5.8	100
Total mineral manufacturing	9.0	73.2	3.3	26.8	12.3	100

Source: Corporations and Labour Unions Returns Act, Report for 1970 Part I – Corporations, Statistics Canada.
– Nil

RETURN ON INVESTED CAPITAL
AVERAGE 1962 - 1970

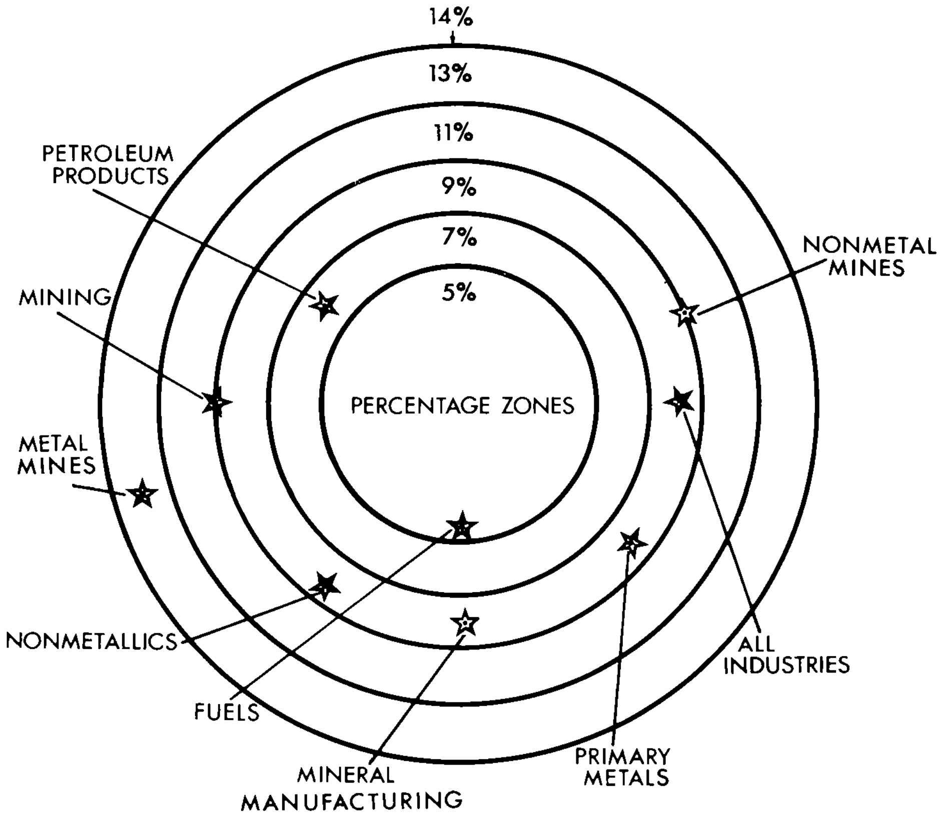


Figure 15

been able to claim, during the full life of the operation, an automatic depletion allowance which is equal to one-third of the taxable income. In general, the effect of the automatic percentage depletion allowance is to reduce the tax otherwise payable by one-third. The automatic percentage depletion allowance will continue to apply until the end of 1976. Beginning in 1977, the automatic percentage depletion allowance will be replaced by an earned depletion allowance. The rate at which the earned depletion allowance may be deducted annually will remain at one-third of the otherwise taxable income. However, the total amount of the allowance which may be deducted will be limited to the base or pool which is earned through eligible expenditures. The depletion base will amount to $1 for every $3 of expenditures on exploration and development activities, on certain assets acquired for a new mine or major expansion, and on facilities acquired to process, up to the prime metal stage, ores which were previously exported from Canadian mineral resources. Depletion may be earned on eligible expenditures between November 7, 1969 and the end of 1976 and accumulated for deduction after 1976.

Mining and petroleum companies will continue to have the right to claim costs of exploration and development incurred in the search for oil, gas or minerals in Canada as an immediate deduction from income from all sources. The cost of mineral properties will be classified as exploration expenses and immediately deductible. The cost of mineral properties will not earn depletion. Revenue from the sale of

Table 4. Annual Changes in Employment, by Industry 1969-72

Industry	1969	1970	1971	1972
		(thousands of persons)		
Agriculture	–10	–24	– 1	–29
Other primary industries	– 4	1	6	– 7
Forestry	1	– 8	0	– 2
Fishing and trapping	– 3	– 1	2	– 1
Mines, quarries and oil wells	– 2	10	4	– 5
Manufacturing	65	–28	5	62
Construction	12	–11	24	6
Sub-total, goods-producing industries	62	–61	33	32
Transportation and communication	17	4	12	22
Electric power, gas and water utilities	3	– 5	– 2	6
Trade, retail and wholesale	32	28	9	80
Finance, insurance and real estate	24	15	20	0
Community, business and personal services	88	107	93	76
Public administration	16	11	35	33
Sub-total, service-producing industries	181	160	167	218
Total, all industries	243	99	200	250

Source: Economic Review, April 1973, Department of Finance.

mineral properties will be treated as income.

Prospectors and their financial backers are no longer exempt from income tax on receipts from the sale of a mining property, but receipts in the form of shares will be classified as a capital gain upon sale of the shares. Only one-half of a capital gain is subject to income tax. The tax liability of the prospector may be further reduced through purchase of a forward-averaging annuity contract. Prospectors may deduct exploration costs, at the rate of 20 per cent annually, from other income.

The general corporate tax rate which was 50 per cent in 1972 will be reduced by one percentage point each year until it reaches 46 per cent for 1976 and subsequent years. The federal government abates to the provinces 10 points of the corporate tax rate. Beginning in 1977, the abatement to the provinces in the case of mining companies will be increased by 15 percentage points, reducing the federal corporate tax rate on mining companies to 21 per cent. At that time, the provinces will be in a position to occupy 25 percentage points of the corporate income tax rate on mines.

A further amendment to the Income Tax Act in July, 1973, provides for a reduction in the general corporate tax rate for manufacturing and processing to 40 per cent, together with a two-year write-off on machinery, equipment and buildings. These benefits will apply to the processing of minerals only beyond the prime metal stage. Custom processors of minerals, not owning a mineral resource, will be eligible for the automatic depletion allowance as from January 1, 1973 and will be eligible to earn depletion for deduction after 1976 through expenditures on processing machinery and equipment acquired after 1972.

Review by provinces*

British Columbia. In 1972 the value of mineral production reached a record of $672.8 million, a gain of 23.8 per cent over $543.7 million for the previous year. Copper continued to be the leading commodity. Its production value increased significantly by 69.3 per cent and it attained its largest proportion of the total output, 37.3 per cent. It was followed by coal production value which increased 56.7 per cent and represented 10.7 per cent of the total. Petroleum declined slightly and represented 9.4 per cent of the total value. The value of structural materials production declined by 1.1 per cent representing 8.8 per cent of the total value. Zinc production accounted for 7.6 per cent of the total and it was fifth place in mineral production value. Natural gas production increased 19.8 per cent accounting for 6.5 per cent of the total value of mineral production. Molybdenum production declined by 11.9 per cent and lead was down 13.4 per

* This section was written by Keith J. Stewart of Resource Development Division, Mineral Development Sector.

cent in terms of value of production.

Four mines suspended operations and closed during 1972. Among the four were two molybdenum producers and two copper producers. To more than offset these losses four large producers began production. Gibraltar Mines Ltd., a subsidiary of Placer Development Limited, started tune-up operations in March at its copper-molybdenum mine at McLeese Lake in the Cariboo district. Lornex Mining Corporation Ltd. began mill tune-up in April at its open pit copper-molybdenum mine, 33 miles south of Ashcroft. Also during the year the copper mine of Similkameen Mining Company Limited at Princeton and the Bell copper deposit of Noranda Mines Limited were brought into production. A smaller silver-zinc-copper mine was brought into production by Bralorne Resources Limited in the Owen Lake area about 28 miles south of Houston.

Production of natural gas and crude petroleum continued at about the same level as last year, dropping slightly for crude petroleum and increasing 19.8 per cent for natural gas.

Zinc production declined by 38 million pounds. However this loss was compensated by increased prices so that the total value of production declined only 0.2 per cent. Cominco Ltd. mined most of the province's zinc and lead and this production, along with concentrates from many other mines throughout Canada, is converted at the company's metallurgical plants to refined zinc, lead and silver and the byproducts antimony, bismuth, cadmium, tin, iron and sulphur compounds. Cominco Ltd. announced that it will close its iron ore, ironmaking and steelmaking facilities at Trail because damage to its larger furnace by an explosion makes continued operations uneconomic.

The coal mining industry of the province continued to increase its productivity during the year. In April, Fording Coal Limited began coal production at its Fording River coal mine 35 miles north of Natal along the Fording River. The quantity of coal mined in the province increased by 56.7 per cent over the previous year. Most of the province's coal output will continue to be exported to Japan for metallurgical purposes. The continuing development of coal mining and its related transportation facilities will have a long-term buoyant effect on the economy of western Canada.

Yukon Territory and Northwest Territories. The value of mineral production in the Yukon Territory increased to $108.5 million from $93.1 million recorded in 1971. Over 85 per cent of the value of production was provided by the metallic mineral sector and most of that through the output of zinc and lead which increased 31.3 per cent in value. There are two zinc and lead producers in the Yukon, Anvil Mining Corporation Limited at Ross River and United Keno Hill Mines Limited at Elsa.

Copper production ceased during 1972 due to the closure of Whitehorse Copper Mines Ltd. in 1971. Late in the year Whitehorse Copper resumed production however no production statistics are available to date. Nonmetallic mineral production was represented by asbestos shipped from the Clinton Creek operation of Cassiar Asbestos Corporation Limited. Shipments of asbestos increased in total value by $1.8 million and in quantity by 1,200 tons.

In the Northwest Territories, mineral output increased in value to $133.0 million from $115.6 million in 1971. Metallic minerals accounted for almost all the production. Zinc and lead, the leading commodities, comprised 79.5 per cent of the output value and were produced in lower amounts from the Pine Point area south of Great Slave Lake by Pine Point Mines Limited, a subsidiary of Cominco Ltd. Shipments of zinc, at $80.1 million, accounted for 60.2 per cent of the total value of minerals. During the year the Northwest Territories maintained its position in third place among the lead producing regions of Canada and also recorded a slight drop in shipments. Gold output from mines in the Yellowknife area increased in value to $16.6 million from $10.9 million for the previous year. The value of silver production increased to $7.3 million from $4.6 million in 1971.

The fifth leading commodity, crude petroleum, represented 0.9 per cent of the production value. Petroleum and natural gas have spurred considerable exploration activity on the Arctic Islands and near the Arctic coast. Significant discoveries were made in 1972.

Alberta. In terms of value of production, this province maintained its position as the leading mineral producing region in Canada in 1972. It increased the value of mineral output by 19.3 per cent over that of 1971 to a total of $1,957.8 million. It continued as the leading producer of crude petroleum, natural gas and its byproducts, and elemental sulphur. Those commodities accounted for 94.8 per cent of the total value with crude petroleum leading the list at $1,272.3 million and providing 65.0 per cent of the total. Natural gas and natural gas byproducts were next in importance and experienced substantial gains to $329.9 million and $238.8 million, respectively. The production value of structural materials increased by 5.3 per cent in 1972. The value of sulphur shipments was again down in 1972 registering a decline of 12.8 per cent in value as a result of extremely low prices caused mainly by an international over-supply situation. The value of coal output increased 20.4 per cent and Alberta continued as the largest national producer of this commodity.

Petroleum exploration activity has declined in western Canada as interest and activity have shifted to northern and offshore areas. Alberta's reserves-production ratio is declining indicating a consumption rate greater than the discovery rate. The Canadian Petroleum Association has estimated Canada's reserves of liquid petroleum will last another 21 years at 1971 rates of production. Reserves of natural gas are sufficient to last 32 years at 1971 levels of use.

Saskatchewan. Saskatchewan's mineral production reached $420.8 million in 1972, up 2.9 per cent from 1971. Some mineral commodities experienced significant advances or reverses as compared with the previous year. Crude petroleum, the leading commodity, had a slight advance in value to $218.2 million and represented 51.9 per cent of the total. Potash followed in order of value and increased 4.1 per cent over its 1971 output to account for 33.4 per cent of the provincial total. This province provides all of Canada's potash and is responsible for this country being the leading world producer.

Copper, the next commodity in importance, increased 12.9 per cent in value and accounted for 3.2 per cent of the provincial total. Structural materials moved from third to fourth place in value, accounting for 2.8 per cent of the total value. The value of natural gas production declined, accounting for 2.1 per cent of the total value of mineral production. Coal production accounted for 1.6 per cent of the provincial total, a slight decline from the previous year. Zinc production value increased by 118.5 per cent, accounting for 1.5 per cent of the provincial total.

Manitoba and Saskatchewan Coal Company (Limited) announced plans to develop a new lignite mine at Estevan. Start-up is scheduled for January 1974 at an annual rate of about 1.8 million tons. All the coal produced from this mine will be sold to the nearby power plant of Saskatchewan Power Corporation.

Gulf Minerals Canada Limited proceeded with development work at its Rabbit Lake property, near the west end of Wollaston Lake. Activities consisted of the construction of foundations, some site preparation and the installation of temporary warehouse and maintenance facilities. Construction of the 4.5 million pound U_3O_8 per year mill will begin in 1973; production is scheduled for 1975.

The White Lake copper-zinc mine of Hudson Bay Mining and Smelting Co., Limited was put in production in June 1972, replacing output from the company's copper-zinc-silver-gold Flexar mine that closed in October. The Waden Bay copper mine of Anglo-Rouyn Mines Limited ceased production in August due to depletion of ore.

Manitoba. The value of mineral output from Manitoba reached $311.09 million in 1972, a decline of 5.5 per cent over the previous year. The two leading commodities, nickel and copper, which were valued at $179.1 million and $59.2 million respectively accounted for 76.4 per cent of the total mineral value. Nickel production value declined 15.0 per cent whereas copper production value increased 1.4 per cent. There was an increase of 6.0 per cent in the output of structural materials and an increase of 109.5 per cent in the value of zinc output, the two commodities next in importance. The value of crude petroleum production declined 5.9 per cent to account for 4.7 per cent of the total value of mineral production. Other mineral commodities such as tantalum, cobalt and gold contributed in that order, but to a minor extent, to the value of provincial mineral output.

The International Nickel Company of Canada, Limited (INCO) operated three nickel mines, the Thompson, Pipe and Birchtree, a smelter and refinery in the Thompson area. Sherritt Gordon Mines, Limited continued to ship nickel and copper from its Lynn Lake operation and copper-zinc from its Fox Lake operation. Development continued at Sherritt's Ruttan Lake copper-zinc deposit about 140 miles northeast of Flin Flon. Production is planned for July 1973 at a rate of 10,000 tons a day.

Hudson Bay Mining and Smelting Co., Limited operated nine copper-zinc mines in the province. The mineral concentrates shipped from those mines are smelted and refined, along with concentrates received on a custom basis, at the company's copper-zinc smelter at Flin Flon.

Ontario. The value of Ontario's mineral production declined by $12.0 million in 1972 reaching a total of $1,542.2 million. A similar decline was registered the previous year. During 1972, nickel and copper accounted for 52.2 per cent of the total value of the province's mineral output. The value of nickel declined 12.1 per cent to $513.3 million and the value of copper declined 8.2 per cent to $291.6 million. In decreasing order of value, the other leading mineral commodities were structural materials, iron ore, zinc, gold, platinum and silver.

During 1972 Ecstall Mining Limited, a wholly-owned subsidiary of Texas Gulf, Inc., began operations at its new electrolytic zinc plant at Timmins. This plant has an annual rated capacity of 120,000 tons of refined zinc and will also have facilities for producing refined cadmium and sulphuric acid. The zinc-copper-lead mining operations of Mattabi Mines Limited, about 200 miles northwest of Thunder Bay were officially opened in September. The mine is producing at designated capacity of 3,000 tons a day. Late in the year the Shebandowan nickel-copper-platinum mine of The International Nickel Company of Canada, Limited in Hagey Township began production. Falconbridge Nickel Mines Limited announced that it planned to close its nickel-iron pellet refinery at Falconbridge in January 1973.

Many other mineral commodities are produced in Ontario which supplies a greater variety than any other province. The northern part of this province continues to provide significant exploration activity and additional new discoveries are being explored or developed for production.

Quebec. The production value of minerals in Quebec increased by 1.2 per cent. Copper continued to be the most dominant commodity and its value provided 22.4 per cent of the province's total value, or $174.2 million. This was a decline of 10.8 per cent from the 1971 value. Contributing to this decline was the closure of the copper-nickel mine of Renzy Mines Limited in Hainaut Township. Also late in the year the Sullivan Mining Group Ltd. announced it would close the Weedon copper-zinc mine, 20 miles south of Thetford Mines, early in 1973. With the completion of a bridge across the Bell River, the Garon Lake zinc-copper mine or Orchan Mines Limited began production late in 1972.

Asbestos was the second mineral commodity in importance and provided 21.2 per cent of the provincial value of mineral production. The total value of asbestos production increased 6.0 per cent from the previous year. Expansion activity continued at the existing operations of Canadian Johns-Manville Company, Limited, Bell Asbestos Mines, Ltd. and at the King-Beaver operation of Asbestos Corporation Limited. Highlight of the year was the beginning of production and shipment from the Asbestos Hill Mine of Asbestos Corporation 30 miles south of Deception Bay, Ungava. Shipments from Asbestos Hill consist of partially milled fibre destined for final processing at Nordenham, West Germany.

Structural materials increased substantially over last year and accounted for 17.6 per cent of the province's value of mineral production. Westroc Industries Limited of Clarkson, Ontario, announced its intention to construct a $7-million gypsum wallboard manufacturing plant on the south shore of the St. Lawrence River, opposite Montreal at Ste-Catherine-d'Alexandrie.

Iron ore output accounted for 12.7 per cent of the value of mineral output. This was a decline of 10.5 per cent from the previous year and was caused chiefly by labour strikes during the year. Two major projects announced for Quebec in 1970 continued during the year. Iron Ore Company of Canada was constructing a new concentrator and pellet plant at Sept-Iles, and Quebec Cartier Mining Company was constructing a concentrator at Mt. Wright. The expenditure for these projects will be in the order of $440 million over the next few years and will provide increases in employment.

Other leading commodities were zinc, titanium dioxide, iron remelt and gold in that order. Quebec produces many other mineral commodities and has pioneered such industries as those relating to titanium dioxide, columbium and lithium.

Exploration activity continued at a generally high level during 1972 and related to a diversity of minerals. The large areas of potential mineral wealth, some of which are relatively unexplored, will assure a continuing significant level of mining activity in Quebec.

In September the Lacorne mine and mill of Molybdenite Corporation of Canada Limited ceased operation. The company had been assisted financially for about a year by the provincial government in the interest of employment. The future of the operation is uncertain.

New Brunswick. The mineral output of New Brunswick is closely related to the production of zinc and its co-products. In 1972 the total value of mineral production increased substantially by 23.3 per cent from the previous year to a total of $132.1 million. Zinc accounted for almost 60 per cent of the total and, along with its co-products lead, copper, silver, calcium, bismuth and gold, it represented 86.3 per cent of the overall mineral value. The value of zinc output was up 46.3 per cent. The value of lead, the second leading commodity was down 9.4 per cent. The production of structural materials, the third leading commodity, was up 19.0 per cent accounting for 8.2 per cent of the total value. Copper production declined 11.6 per cent and silver production increased 14.2 per cent. Coal output from the declining Minto coal fields decreased by 11.4 per cent in value to account for 2.6 per cent of the provincial total.

Brunswick Mining and Smelting Corporation Limited is the province's largest producer of base metals and operated two zinc-lead-copper mines with mill near Bathurst. Conversion of the company's Belledune smelter from an Imperial Smelting process to a straight lead blast furnace, changing its capacity for primary lead metal from 30,000 to 70,000 tons a year was nearing completion at year-end. Another important base metals producer is Heath Steele Mines Limited with mines located northwest of Newcastle. Heath Steele sustained a 2-month labour strike during the year causing losses in the province's base metal production. Consolidated Durham Mines & Resources Limited remodeled its mill, cutting capacity, and installed pollution abatement equipment at its Lake George antimony property and resumed production, after a 3-month closure.

Sullivan Mining Group Ltd. announced in January 1972 it would close the strike-bound lead-zinc-copper-silver mine and 1000-ton-a-day mill of Nigadoo River Mines Limited near Bathurst. A total of 317 employees was affected. The Sullivan Group continued to maintain activity in the Mt. Pleasant area where tin mineralization occurs.

The Swedish firm, Boliden Aktiebolag continued detailed exploration on the St. Stephen copper-nickel-cobalt deposits.

The province continued negotiations with companies interested in exploring and developing the Sussex potash deposits. The discovery of potash near Sussex was made in 1971 as a result of drilling which was part of a mineral exploration program funded by the federal Department of Regional Economic Expansion. Another part of the DREE program was an airborne geophysical survey which generated the staking of 600 mineral claims in the Caledonian area of the province.

During the year, Noranda Mines Limited purchased the remaining 50 per cent interest in Belledune Fertilizer Limited from the Albright and Wilson Group of Britain for $4 million.

Nova Scotia. Nova Scotia's mineral output was valued at $54.6 million in 1972, representing a decline of 9.2 per cent from 1971. One hundred per cent of the total was provided by fuels, structural materials and nonmetallic minerals. Coal, the leading commodity, accounted for 30.2 per cent, registering a decline of 28.4 per cent to a total value of $16.4 million. In February 1972, Cape Breton Development Corporation announced the formal closing of the No. 20 colliery located at Glace Bay. It had been idle since July 1971. Cape Breton Development Corporation's McBean colliery at Thorburn was closed at the end of June 1972. Small scale mining was started at the new Lingan coal mine near New Waterford. Full production is scheduled for 1974.

Structural materials decreased slightly in value from 1971 and accounted for 28.9 per cent of the provincial total. Gypsum retained its position and provided 24.0 per cent of the overall value. Nova Scotia provides about 75 per cent of Canada's gypsum and is one of the leading gypsum producing areas in the world. Salt production value experienced a decline providing 15.8 per cent of the province's value of production. Barite production declined considerably accounting for 0.5 per cent of the total value of mineral production. Dresser Minerals Division of Dresser Industries, Inc. at Walton announced permanent closure of its lead mining operation in August 1972 following flooding of the mine in late 1971.

Off Nova Scotia's east coast, a new wet gas discovery was made 7 miles southwest of the previous discovery on the western tip of Sable Island. The new well, Mobil Tetco Thebaud P-84 recovered significant flows of gas from five separate zones, some of which also produced condensate. The team of Mobil Oil Canada, Ltd. and Texas Eastern Transmission Corporation is currently using a drilling platform on the western end of the island to develop the oil and gas field they discovered in 1971. In addition to this activity, there were four semisubmersible drilling rigs operating off the east coast of Canada at the end of 1972.

Prince Edward Island. Prince Edward Island's mineral production has historically been confined to structural materials. The value of production decreased 18.2 per cent to $800,000 from a total of $978,000 for the previous year. Production was confined solely to the output of sand and gravel.

Newfoundland and Labrador. Newfoundland's total mineral production was valued at $303,851 million in 1972, a decline from $343.4 million in 1971. Iron ore continued to play a major role in the mineral industry of Newfoundland accounting for 80.7 per cent of the total value of provincial mineral production. Newfoundland is by far the largest producer of iron ore in Canada, the mines and concentrators being operated by Iron Ore Company of Canada and Wabush Mines.

Asbestos, the mineral commodity second in value of output, increased in value by 4.0 per cent to account for 4.3 per cent of the provincial total. The province's only asbestos producer is Advocate Mines Limited, located at Baie Verte.

Copper, the mineral commodity third in value of production, declined 27.2 per cent to account for 3.5 per cent of the provincial total. Zinc production increased 51.0 per cent, also accounting for 3.5 per cent of the value of mineral production. Likewise lead production value increased 46.2 per cent accounting for 1.8 per cent of the provincial total. The increases registered by zinc and lead were due to the resolution of labour problems that resulted in a strike at the operations of the Buchons Unit of American Smelting and Refining Company for six months in 1971.

Lightweight Aggregates

D. H. STONEHOUSE

Traditional aggregates for use in concrete and concrete products have been sand and gravel. As concrete technology advanced, the need for clean, sharp aggregate with a designed particle size distribution was emphasized and the use of crushed stone aggregate as well as crushed, screened and washed gravel became standard procedure. The methods of mixing, transporting, placing and curing of concrete are the subject of ongoing studies and research in conjunction with the use of various types of cement as the binding media. Until the mid-forties, comparatively little attention was paid to designing concrete products to meet a specific requirement other than a certain predetermined strength and setting time. At that time increased housing demand accentuated the need for prefabricated structures. Techniques of construction were developed using structural sections and panels of much lighter unit volume, with no sacrifice of strength, by utilizing lightweight aggregates which also incorporated the added advantage of insulation from heat, fire, sound and moisture. The use of lightweight concrete in commercial and institutional projects has enabled the construction of much taller buildings and the use of longer clear spans.

Four categories generally used to classify the lightweight aggregates combine elements of source, processing methods and end use. Natural lightweight aggregates include materials such as pumice, scoria volcanic cinders and tuff. Manufactured lightweights are bloated or expanded products obtained by heating certain clays, shales or slates. Ultralightweights are made from natural mineral ores, such as perlite and vermiculite, which are expanded or exfoliated by the application of heat and used mainly as plaster aggregate or as loose insulation. Fly ash, obtained from the combustion of coal and coke, and slag obtained from metallurgical processes are classed as byproduct aggregates.

All types are used in Canada but only expanded clays, shale and slag are produced from materials of domestic origin. Vermiculite is imported mainly from Montana, U.S.A., although a small amount is brought in from South Africa; perlite is imported mainly from New Mexico and Colorado and pumice is imported from the State of Oregon and from Greece.

Canadian industry and developments

With total construction spending in Canada showing continued increases and with the general trend towards higher buildings, larger precast shapes and greater clear spans, the application of lightweight aggregates in concrete should increase greatly. The advantages of location and cost enjoyed by the normal heavy aggregates are becoming less of a factor as sources of good-quality aggregates close to the consuming centres are becoming scarce, land-use conflicts are more evident and transportation costs continue to increase.

Perlite. Perlite is a variety of obsidian or glassy volcanic rock that contains 2 to 6 per cent of chemically combined water. When the crushed rock is heated rapidly to a suitable temperature it expands to between four and twenty times its original volume. Expanded material can be manufactured to weigh as little as 2 to 4 pounds a cubic foot with attention being given to preblending of feed to the kiln and retention time in the flame.

In Canada imported perlite is expanded and used mainly by gypsum products manufacturers. In 1972 about 29 per cent of consumption was in plaster products such as wallboard or drywall, where its value as a lightweight material is augmented by its fire-resistant qualities. It is also used as a loose insulation and as an insulating medium in concrete products. Perlite, as well as vermiculite and expanded shale and clay, is becoming more widely used in agriculture as a soil conditioner and fertilizer carrier.

Imports of crude perlite for consumption in Canada are from New Mexico and Colorado deposits worked by such companies as Johns-Manville Corporation, United States Gypsum Company, United Perlite Corp. and Grefco Inc. In 1972 seven companies at eight locations in Canada reported production of expanded perlite.

Perlite occurs in British Columbia but no commercial deposits have as yet been located.

Pumice. Pumice is a cellular, glassy lava, the product of explosive volcanism, usually found near geologically recent or active volcanoes. It is normally found as a loosely compacted mass composed of pieces ranging in size from large lumps to small particles. It is not the lightest of the lightweight aggregates, but when utilized as a concrete aggregate, particularly for the manufacture of concrete blocks, it exhibits strength,

Table 1. Canada, production of lightweight aggregates, 1971-72

	1971		1972	
	(cu. yd)	($)	(cu. yd)	($)
From domestic and imported raw materials:				
expanded clay, shale and slag and exfoliated vermiculite	1,080,895	7,142,376	1,322,514	10,071,566
From imported raw materials				
Expanded perlite	103,155	1,117,062	84,924	986,336
Pumice	30,100	173,000	5,850	33,345
Total	1,214,150	8,432,438	1,413,288	11,091,247

Source: Company data.

density and insulating values that have made it a preferred material.

In Canada a number of concrete products manufacturers use pumice imported from Greece or from northwestern United States mainly in the manufacture of concrete blocks. A major use for pumice, as yet unexplored in Canada, has been in highway construction where lightweight aggregate surfaces have been shown to have exceptional skid resistance.

Pumicite, distinguished from pumice by its finer size range (usually minus 100 mesh), is used in concretes mainly for its pozzolanic qualities. (A pozzolan is a siliceous material possessing no cementitious qualities until finely ground, in which form it will react with calcium hydroxide in the presence of moisture to form insoluble calcium silicates.)

Extensive beds of pumicite have been noted in Saskatchewan and in British Columbia.

Table 2. Canada, consumption of expanded clay and shale

	1970	1971	1972
	(per cent)		
Concrete			
Block	61	69	70
Precast structural	5	3	3
Cast-in-place structural	30	27	24
Minor uses			
Sand blasting, horticulture refractories, insulation brick grog, flexible pavement	4	1	3

Source: Company data.

Vermiculite. The term vermiculite refers to a group of micaceous minerals, hydrous magnesium-aluminum silicates, that exhibit a characteristic lamellar structure and that expand or exfoliate greatly upon being rapidly heated. Mining is normally by open-pit methods and beneficiation techniques include the use of hammer mills, rod mills, classifiers, screens, dryers and cyclones. Exfoliating is done in oil- or gas-fired, vertical or inclined furnaces, usually close to the consuming facility to obviate the higher costs associated with shipping the much bulkier expanded product. The expansion process has advanced technologically to permit production of various grades of expanded vermiculite as required. The uses to which the product are put depend on its low thermal conductivity, its fire-resistance and more recently on its lightweight qualities.

Canadian consumption is mainly as loose insulating material, with smaller amounts being used as aggregate in insulating plaster and concrete. The major producer of vermiculite is the United States; the principal company supplying Canada's imports is W. R. Grace and Company from operations at Libby, Montana. Canada also imports crude vermiculite from South Africa where Palabora Mining Co. Ltd. is the major producer.

Table 3. Canada, consumption of expanded perlite

	1970	1971	1972
	(per cent)		
Insulating plaster	62	64	29
Insulation	17	22	20
Insulating concrete	7	3	21
Agriculture, horticulture	–	11	29
Other uses: fillers	14	–	1

Source: Company data.

Table 4. Canada, consumption of exfoliated vermiculite

	1970	1971	1972
	(per cent)		
Loose insulation	63	72	72
Insulating plaster	14	9	5
Insulating concrete	11	10	15
Minor uses			
Fireproofing, agriculture, underground pipe insulation, horticulture, barbecue base	12	9	8

Source: Company data.

The Geological Survey of Canada reports occurrences of vermiculite in British Columbia and in Ontario but as yet no commercial deposits have been developed in Canada.

Clay and shale. Common clays and shale are used throughout Canada as raw material for the manufacture of lightweight aggregates. Although the Canadian industry began in the 1920's in Ontario, it did not evolve significantly until the 1950's when it grew in support of demands from the construction industry. The raw materials are usually quarried adjacent to the plant sites at which they are expanded. Clay receives little beneficiation other than drying before being introduced to the kiln. Shales are crushed and screened before burning. Nine plants in Canada currently produce lightweight aggregates from clay and shale, using a rotary kiln process.

One company produces an aggregate material from slag as a byproduct of a blast furnace operation. In the steel-making process, iron ore, coke and limestone flux are melted in a furnace. When the metallurgical process is completed, lime has combined with the silicates and aluminates of the ore and coke and formed a nonmetallic product (slag) which can be subjected to controlled cooling from the molten state to yield a porous, glassy material. Slag has many applications in the construction industry. The statistics relative to expanded slag production are included in those of clay and shale.

Although Canada does not produce large amounts of fly ash, the technology of fly ash processing and utilization is well advanced. The largest single use for fly ash is as a cementitious material where its pozzolanic qualities are utilized. Use of fly ash as a lightweight aggregate could become of increasing importance. International Brick and Tile Ltd. of Edmonton, Alberta, which produces brick using fly ash and bottom ash as raw material, was taken over by Great West Steel Industries Ltd. of Vancouver in 1972. Great West plans to expand the Wabamun plant at a cost of $1.2 million.

About half of the 400,000 tons a year of fly ash collected at Ontario Hydro's Lakeview thermal generating plant is to be utilized in the production of pozzolan, iron oxide and lightweight aggregate pellets.

There are as yet no Canadian Standard Association (CSA) specifications for the lightweight aggregates. Production and application are based on American Society for Testing and Materials (ASTM) designations as follows: ASTM Designation C 332-56 T – Lightweight Aggregates for Insulating Concrete; C 330 – Lightweight Aggregates for Structural Concrete; C 331 – Lightweight Aggregates for Concrete Masonry Units.

Outlook

Demand for all lightweight aggregates will continue to increase as use in structural concrete and for insulation purposes becomes more popular. The four main lightweight materials – perlite, pumice, vermiculite and expanded clays – are interchangeable for many applications and can, along with some synthetic materials, be considered substitutes or alternates for each other.

The United States is the source of most of the lightweight raw materials consumed in Canada, exclusive of clay, shale and slag. The U.S. reserves are sufficient both for its domestic requirements and for exports to meet Canada's projected needs for many years.

World review

The United States and Greece are the main producers of perlite with smaller quantities mined in Algeria, Turkey, the Philippines and New Zealand. The last country could become a major producer if huge deposits owned by Consolidated Silver Mining Co. are developed for export markets.

The major producers of pumice include the United States, Italy, West Germany and Greece although production is recorded from other countries. As with other low-cost lightweight material, transportation costs are the main factors in determining the competitiveness of pumice. Prices have not varied greatly in recent years.

World production of vermiculite increased by about 10 per cent in 1972. In the United States, W. R. Grace and Company, Zonolite Division is by far the largest producer with mines in Montana and South Carolina. Through the Palabora Mining Co. Ltd. the Union of South Africa remains the second largest producer of vermiculite. The unit price has shown a steady but unspectacular rate of increase during the past few years and is likely to continue to do so in pace with moderate increase in demand.

W. R. Grace and Company has indicated its

Table 5. Lightweight aggregate plants in Canada, 1972

Company	Location	Product
Atlantic provinces		
Avon Aggregates Ltd.	Minto, N.B.	Expanded shale
Quebec		
F. Hyde & Company, Limited	Montreal	Vermiculite
Laurentide Perlite Inc.	Charlesbourg West	Perlite
Miron Company Ltd.	Montreal	Pumice[1]
Perlite Industries Reg'd.	Ville-St-Pierre	Perlite
Vermiculite Insulating Limited	Lachine	Vermiculite
Ontario		
Canadian Gypsum Company, Limited	Hagersville	Perlite
Domtar Construction Materials Ltd.	Caldonia	Perlite
	Cooksville	Expanded shale
F. Hyde & Company, Limited	St. Thomas	Vermiculite
Holmes Insulations Limited	Sarnia	Perlite
National Slag Limited	Hamilton	Slag
Prairie provinces		
Cindercrete Products Limited	Regina, Sask.	Expanded clay
Consolidated Concrete Limited	Calgary, Alta.	Expanded shale
Domtar Construction Materials Ltd.	Calgary, Alta.	Perlite
Echo-Lite Aggregate Ltd.	St. Boniface, Man.	Expanded clay
Consolidated Concrete Limited Edcon Block Division	Edmonton, Alta.	Expanded clay
Grace Construction Materials Ltd.	Winnipeg, Man.	Vermiculite
	Regina, Sask.	Vermiculite
	Edmonton, Alta.	Vermiculite
Kildonan Concrete Products Ltd.	St. Boniface, Man.	Expanded clay
Northern Perlite & Vermiculite Limited	St. Boniface, Man.	Perlite Vermiculite
Redi-Mix Concrete Ltd.	Regina, Sask.	Expanded clay
British Columbia		
British Columbia Lightweight Aggregates Ltd.	Saturna Island	Expanded shale
Grace Construction Materials Ltd.	Vancouver	Vermiculite
Ocean Construction Supplies Limited	Vancouver	Pumice[1]
Westroc Industries Limited	Vancouver	Perlite Vermiculite

Source: Company data.
[1] Pumice is used in concrete block manufacture.

Table 6. Canada, construction expenditures, 1970-72

	1970	1971	1972
		(millions of dollars)	
Total building construction	8,098	9,143	9,471
Residential	4,008	4,828	5,184
Industrial	1,000	1,027	908
Commercial	1,287	1,345	1,475
Institutional	1,330	1,474	1,447
Other building construction	473	469	457
Total heavy construction	5,683	6,504	6,870
Marine construction	145	146	201
Road, highway and aerodrome	1,280	1,422	1,510
Waterworks and sewage systems	488	629	664
Dams and irrigation	58	78	69
Electric power construction	1,224	1,308	1,282
Railway, telephone and telegraph	568	608	639
Gas and oil facilities	1,094	1,302	1,385
Other heavy construction	826	1,011	1,210
Total construction	13,781	15,647	16,341
Labour content	4,910	5,656	5,809
Materials cost	5,867	6,658	6,950

Source: Statistics Canada.

intention to expand the Libby, Montana mine at a cost of $6.75 million. The company continues to develop its network of processing and storage facilities. Palabora has installed provisions for the treatment of much finer grades than formerly, allowing a higher degree of utilization of available reserves. Most of its product is shipped to European markets.

The use of fly ash should increase with the added incentives provided by environmental control. Two cement companies in the United States have begun to blend fly ash with portland cement at three plants to produce portland-pozzolan cement for general construction use. Using only about 20 per cent of ash production, industry in North America falls far short of European enterprises, which use as much as 80 per cent of production (Federal Republic of Germany).

Aluminum

D.G. SCHELL

The market for aluminun recovered in 1972 from the depressed levels of the previous year. Output, which was cut back in 1971, was gradually raised to about 88 per cent of capacity in the noncommunist world by the end of 1972. Surplus stocks of primary metal were reduced from a dangerously high accumulation early in the year. However, the price of primary ingot generally remained low, although some finished and semifinished aluminum products achieved moderate increases. With rising operating costs, the result was low profitability for most aluminum producers.

Canada

No economic deposits of bauxite, the predominant ore of aluminum, are found in Canada. All bauxite supplies are imported for the production of alumina by the Bayer process. Alumina is an aluminum oxide intermediate product which is reduced in an electric furnace to aluminum metal by the Hall-Heroult process. Approximately 4.5 tons of bauxite are refined to 2 tons of alumina, which in turn are smelted to 1 ton of aluminum. The Hall-Heroult process consumes vast quantities of electric power, between 7 and 8 kWh per pound of aluminum produced, and Canada's aluminum smelters are advantageously located near large, low-cost power sources. Because transportation costs are such an important factor in the import of raw materials and export of aluminum, these smelters are all located near ocean shipping ports.

Production. Canadian primary aluminum output decreased to 1,012,674 tons* in 1972, 8 per cent less than the previous year. This reduction was caused by excess supply in world markets and a work stoppage at one producer's smelter. Two companies operate primary aluminum smelters in Canada, Aluminum Company of Canada, Limited (Alcan), a subsidiary of Alcan Aluminium Limited, of Montreal (also referred to as Alcan), and Canadian Reynolds Metals Company, Limited, a subsidiary of Reynolds Metals Company of Richmond, Virginia. The Canadian primary aluminum industry was producing at 88 per cent of capacity at year-end.

Some 2,892,000 tons of bauxite were imported from Guyana, Sierra Leone and elsewhere to produce alumina at Alcan's refinery at Arvida, Quebec, the only alumina refinery in Canada. It has a capacity of 1,387,000 tons a year of alumina and supplies Alcan's four smelters in Quebec. Alcan continued to purchase the major part of its bauxite from Guyana in 1972, although less than previously. It is anticipated that early in 1973 imports of bauxite from Alcan's project in Guinea will assume increasing importance.

In 1972 Alcan's five Canadian smelters produced 880,000 tons of aluminum, a decrease of 7 per cent compared with their output of 945,000 tons in 1971. Although operations for 1972 were at an average of only 85 per cent capacity, the operating rate at year-end was 88 per cent, up from an operating rate of 86 per cent at the end of the previous year. Alcan Aluminium Limited, a multinational company, has wholly and partly owned smelters in Norway, Japan, Great Britain, Sweden, Spain, Australia, India, Brazil and Italy. In 1972, ingot production from Alcan's subsidiary and related companies outside of Canada exceeded that from its Canadian smelters for the first time. The company's total production of 1,853,000 tons, including Canadian output, was also down from its 1971 production of 1,880,000 tons.

Canadian Reynolds Metals Company, Limited experienced a 10-week strike at its Baie-Comeau, Quebec smelter. Production was 120,000 tons of aluminum, 24 per cent less than the 158,000 tons produced in 1971. During 1972 the plant operated at 83 per cent of capacity until the work stoppage in June. It operated at about a third of capacity during the strike and was striving for maximum output after settlement of the labour dispute.

Consumption. Canadian consumption of primary aluminum in 1972 was 316,000 tons, 7 per cent more than the 295,000 tons consumed in 1971. This gain was led by aluminum sheet and packaging materials. Although primary ingot production capacity has not been expanded recently, increased domestic consumption has resulted in additional semifabricating facilities being built. Reynolds Aluminum Company of Canada Ltd., another Reynolds subsidiary, is undertaking a $4,800,000 expansion of its rolling mill at Cap-de-la-Madeleine, Quebec. Alcan's subsidiary, Alcan Canada Products Limited, has doubled the size of its extrusion plant at Laval, Quebec, to 8,000 tons a year. In 1971 this subsidiary opened its hot-rolling mill at Arvida which embodies a new concept of continuous casting and rolling. However, at the end of 1972 it was still operating well below its 70,000-ton-a-year capacity.

*All tons are short tons of 2,000 pounds unless otherwise specified.

Table 1. Canada, aluminum production and trade, 1971-72

	1971		1972p	
	(short tons)	($)	(short tons)	($)
Production	1,104,644		1,012,674	
Imports				
Bauxite ore				
Guyana	2,287,614	19,302,000	1,760,739	14,495,000
Surinam	329,159	4,990,000	338,690	5,317,000
Sierra Leone	64,068	461,000	385,442	2,692,000
United States	17,909	505,000	28,915	787,000
Other countries	16,371	105,000	377,725	1,913,000
Total	2,715,121	25,363,000	2,891,511	25,204,000
Alumina				
United States	303,638	20,935,000	273,238	18,586,000
Jamaica	369,702	25,349,000	228,299	15,878,000
Australia	285,664	19,751,000	239,139	15,739,000
Guyana	60,678	3,872,000	654	41,000
Other countries	492	167,000	112	33,000
Total	1,020,174	70,074,000	741,442	50,277,000
Aluminum and aluminum alloy scrap	6,414	1,340,000	8,179	1,082,000
Aluminum paste and aluminum powder	1,422	860,000	2,029	1,261,000
Pigs, ingots, shots, slabs, billets, blooms, and extruded wire bars	17,527	9,797,000	38,300	18,899,000
Castings	861	1,881,000	705	1,436,000
Forgings	965	2,318,000	474	1,594,000
Bars and rods, nes	4,126	2,640,000	5,715	3,643,000
Plates	13,730	8,563,000	16,027	9,675,000
Sheet and strip up to .025 inch thick	13,515	9,933,000	16,945	12,084,000
Sheet and strip, over .025 inch up to .051 inch thick	4,039	3,328,000	6,382	5,115,000
Sheet and strip, over .051 inch up to .125 inch thick	43,460	23,613,000	34,771	18,993,000
Sheet and strip over .125 inch thick	18,079	10,637,000	19,156	11,236,000
Foil or leaf	1,102	1,141,000	1,103	1,143,000
Converted aluminum foil	..	2,257,000	..	2,931,000
Structural shapes	2,856	5,783,000	2,596	5,330,000
Pipe and tubing	801	1,328,000	991	1,648,000
Wire and cable, excluding insulated	1,783	1,582,000	1,222	1,319,000
Aluminum and aluminum alloy fabricated materials, nes	..	6,484,000	..	7,379,000
Total aluminum imports		188,922,000		180,249,000
Exports				
Pigs, ingots, shot, slab, billets, blooms, and extruded wire bars				
United States	449,511	207,347,000	487,609	220,508,000
United Kingdom	104,851	60,569,000	80,523	42,382,000
Japan	104,907	41,578,000	76,881	31,089,000
West Germany	33,588	16,832,000	20,261	9,299,000
Brazil	14,810	6,991,000	13,201	5,714,000
Argentina	24,405	12,125,000	9,598	5,136,000
Italy	7,963	3,826,000	8,879	3,877,000

Table 1 (cont'd)

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Exports (cont.)				
Turkey	13,060	6,425,000	8,872	3,858,000
Belgium and Luxembourg	13,762	7,500,000	6,195	3,166,000
Israel	5,777	2,848,000	7,485	3,097,000
Other countries	117,368	58,830,000	50,649	23,407,000
Total	890,022	424,871,000	770,153	351,533,000
Castings and forgings				
United States	3,575	4,423,000	1,522	3,410,000
France	14	83,000	17	355,000
Japan	–	–	149	40,000
West Germany	13	49,000	2	32,000
Other countries	30	47,000	25	32,000
Total	3,632	4,602,000	1,715	3,869,000
Bars, rods, plates, sheet and circles				
Portugal	3,889	2,182,000	6,940	4,204,000
United States	3,400	2,571,000	3,381	2,266,000
Mexico	1,573	818,000	2,431	1,194,000
New Zealand	3,365	1,955,000	1,904	994,000
Argentina	–	–	1,613	804,000
Jamaica	650	498,000	952	695,000
United Kingdom	35	31,000	742	563,000
Ecuador	89	56,000	292	362,000
Other countries	3,083	2,157,000	2,344	1,991,000
Total	16,084	10,268,000	20,599	13,073,000
Foil				
United States	184	182,000	42	52,000
Jamaica	...	1,000	8	9,000
Mexico	10	17,000	7	8,000
Trinadad–Tobago	1	2,000	4	6,000
West Germany	4	2,000	4	5,000
Other countries	1	2,000	6	7,000
Total	200	206,000	71	87,000
Fabricated materials, nes				
United States	4,112	3,815,000	4,744	4,109,000
Argentina	3,708	1,828,000	5,345	2,786,000
Brazil	2	2,000	1,616	1,368,000
Pakistan	533	516,000	970	1,011,000
Ivory Coast	208	197,000	934	947,000
Other countries	3,160	3,047,000	4,054	3,601,000
Total	11,723	9,405,000	17,663	13,822,000
Ores and concentrates				
United States	16,121	1,816,000	17,828	1,986,000
France	720	89,000	2,887	401,000
Italy	2,841	327,000	1,313	170,000
Spain	565	85,000	1,076	148,000
United Kingdom	530	69,000	744	105,000
West Germany	117	20,000	160	20,000

Table 1 (concl'd)

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Exports (cont.)				
Other countries	325	49,000	319	43,000
Total	21,219	2,455,000	24,327	2,873,000
Scrap				
United States	37,147	12,522,000	45,326	14,531,000
Italy	5,573	1,904,000	5,160	1,543,000
Japan	2,260	533,000	3,738	1,092,000
West Germany	639	169,000	1,826	413,000
South Korea	298	93,000	1,290	397,000
Spain	1,478	316,000	1,259	364,000
Other countries	839	218,000	924	260,000
Total	48,234	15,755,000	59,523	18,600,000
Total aluminum exports		467,562,000		403,857,000

Source: Statistics Canada.
^{p}Preliminary; – Nil; nes Not elsewhere specified; . . Not available; . . . Less than one short ton.

Table 2. Canada, primary aluminum production, trade and consumption, 1963-72

	Production	Imports	Exports	Consumption[1]
	(short tons)			
1963	719,390	1,954	635,187	161,833
1964	842,640	3,996	627,992	172,443
1965	830,505	6,945	707,512	213,094
1966	889,915	16,923	716,382	243,301
1967	963,343	8,176	760,649	217,484
1968	979,171	15,043	862,634	242,390
1969	1,078,717	11,531	886,688	269,027
1970	1,061,020^r	13,425	839,598	275,743
1971	1,104,644	17,527	890,022	322,524
1972^p	1,012,674	38,300	770,153	. .

Source: Statistics Canada.
[1]Including secondary as reported by consumers.
^{p}Preliminary; . . Not available; ^{r}Revised.

World review

In spite of an increase in aluminum output, world bauxite production in 1972 decreased by 6 per cent to 61.9 million tons, down from 66.1 million tons in 1971. This anomaly probably may be explained by aluminum smelters utilizing previously mined bauxite, thus reducing stocks. Nevertheless, there were indications that surplus inventory still existed in 1972 in some producing countries, particularly Australia and Guyana. Australia, with its very extensive reserves, surpassed Jamaica as the largest producer of bauxite and it will probably retain its leading position for the foreseeable future.

Almost all new bauxite deposits in recent years have been developed as part of a bauxite mine-alumina refinery complex, the alumina refinery consuming at least a part of the bauxite mined. An exception which does not have an associated alumina refinery is the large Boke deposit in Guinea, being developed jointly by the Guinean government and a group of six aluminum producers, of which the Aluminum Company of America (Alcoa), Alcan and Martin Marietta Aluminum Inc. are the main shareholders. It is expected to produce 900,000 tons of ore in 1973, increasing to 9,000,000 tons a year by 1979. A new bauxite concentration plant at Itea, Greece was started up by Bauxites Parnasse, S.S., part of a 200,000-ton expansion to increase production to 2,200,000 tons a year. Alumina Surinam Inc., an Alcoa subsidiary, intends to mine bauxite in French Guiana for processing in its plant in Surinam. In the communist countries of Russia, Hungary and Yugoslavia, expansions are taking place in bauxite mining, as well as alumina refining and aluminum smelting.

Expansion of alumina facilities continued in 1972 in spite of a surplus of aluminum raw materials; operators appear to be relying on a future market based on increased aluminum production. At Gove in the Northern Territory of Australia, Nabalco Pty. Ltd. began production at its 550,000-ton-a-year alumina plant which is being expanded to double its capacity.

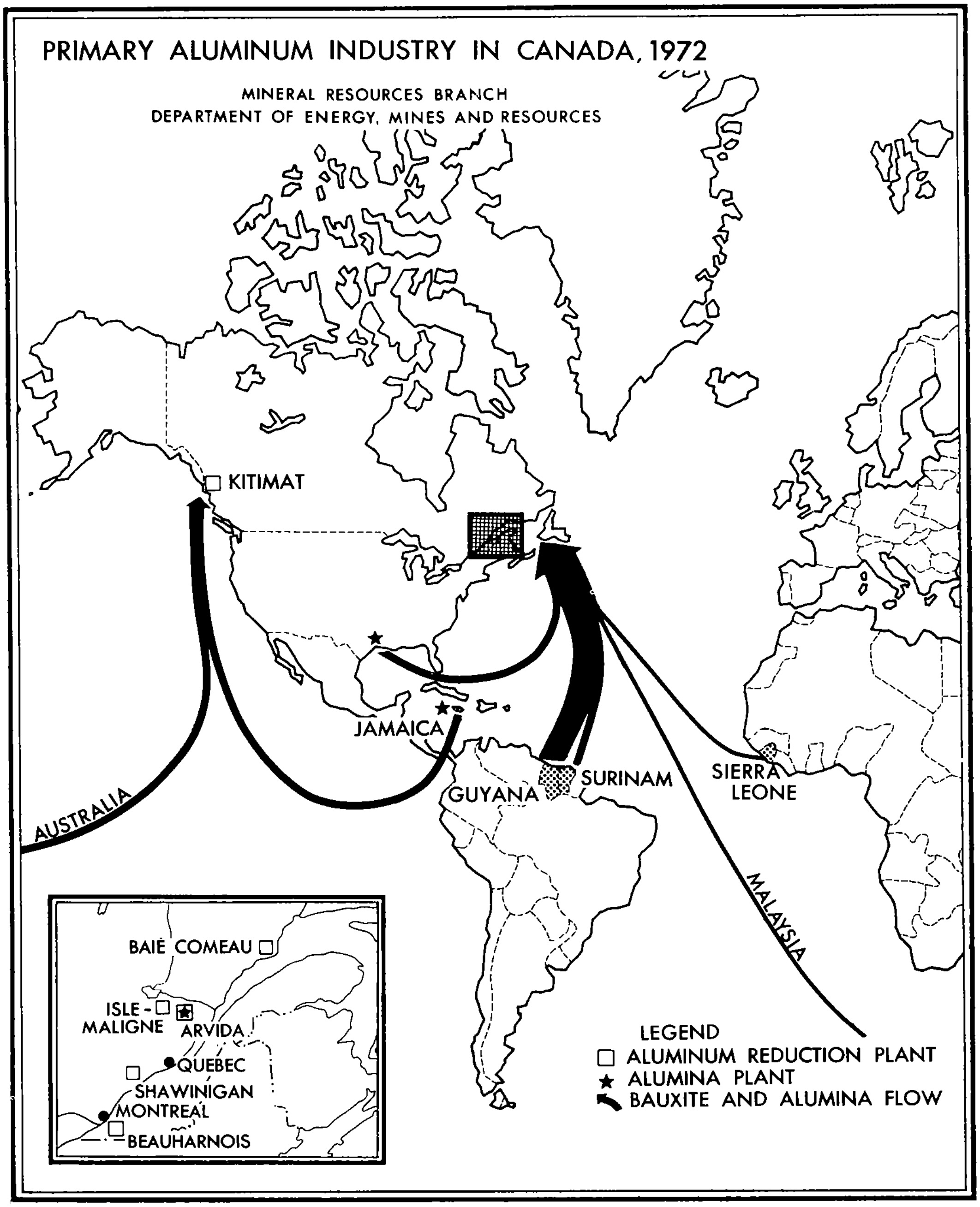

PRIMARY ALUMINUM INDUSTRY IN CANADA, 1972
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
KITIMAT
JAMAICA
GUYANA
SURINAM
SIERRA LEONE
AUSTRALIA
MALAYSIA
BAIE COMEAU
ISLE-MALIGNE
ARVIDA
QUEBEC
SHAWINIGAN
MONTREAL
BEAUHARNOIS
LEGEND
ALUMINUM REDUCTION PLANT
ALUMINA PLANT
BAUXITE AND ALUMINA FLOW

Table 3. Canada, consumption of aluminum at first processing stage

	1969	1970	1971	1972P
	(short tons)			
Castings				
Sand	1,578	1,596	1,486	..
Permanent-mould	12,262	11,574	15,468	..
Die	22,670	19,546	22,763	..
Other	103	73	117	..
Total	36,613	32,789	39,834	..
Wrought products				
Extrusions, including tubing	69,653	64,145	79,179	..
Sheet, plate, coil and foil	82,983	80,598	92,941	..
Other wrought products (including rod, forgings and slugs)	68,525	87,923	98,680	..
Total	221,161	232,666	270,800	..
Destructive uses				
Non-aluminum-base alloys, powder and paste, deoxidizers and other	11,253	10,288	11,890	..
Total consumed	269,027	275,743	322,524	..
Secondary aluminum consumed	34,787	30,035	27,415	..
Receipts and inventories at plants	Metal Entering Plants		On Hand December 31	
	1971	1972P	1971	1972P
Primary aluminum ingot and alloys	287,391	..	68,738	..
Secondary aluminum	31,580	..	2,043	..
Scrap originating outside plant	44,697	..	5,513	..

Source: Statistics Canada.
PPreliminary; .. Not available.

Alcoa of Australia Ltd. opened its 220,000-ton-a-year Pinjarra plant in Western Australia and intends to raise its capacity to 880,000 tons. Also in Australia, expansion of the Queensland Alumina Limited plant at Gladstone, originally scheduled for completion in 1972, was delayed by persistent work stoppages of construction labour and will now be completed in 1973. Currently the world's largest alumina refinery, with a capacity of 1,400,000 tons a year, it will be increased to 2,200,000 tons. In Japan, Nippon Light Metal Company began initial operations at its Tomakomai 400,000-ton-a-year plant and Mitsui Aluminum Company at its 220,000-ton Wakamatsu plant. A 660,000-ton-a-year alumina refinery, owned by Eurallumina SpA, started production in Sardinia. Eventually it will be expanded to 2,000,000 tons. Construction began in West Germany of the Stade alumina refinery of Aluminium Oxid Stade GmbH, scheduled to begin operations in 1973 with a capacity of 770,000 tons a year. A company jointly owned by the Spanish government, Pechiney Ugine Kuhlmann, and Alcan will build an 88,000-ton-a-year alumina plant on the northwest coast of Spain, production to commence in 1977. Taiwan Aluminium Corporation will almost double its alumina plant capacity to 150,000 tons a year in 1975. Additional bauxite and alumina capacity is being developed in India to supply its expanding aluminum industry. On the other hand, the Kimberley bauxite-alumina project in Western Australia was cancelled. American Metal Climax, Inc., the major partner, will obtain its alumina requirements from Alcoa of Australia Ltd., thus contributing

Table 4. World primary aluminum production and consumption, 1971 and 1972

	Production		Consumption	
	1971	1972	1971	1972[e]
	(thousand short tons)			
United States	3,925	4,122	4,316	4,713
Europe[1]	2,542	2,726	2,760	2,984
Japan	984	1,118	1,072	1,278
Canada	1,105	1,013	295	316
Australia and New Zealand	271	323	169	168
Asia (excluding Japan and China)	255	337	360	368
Africa	211	258	83	88
America (excluding U.S. and Canada)	217	227	245	260
Subtotal	9,510	10,124	9,300	10,175
Communist countries[2]	2,482	2,579	2,351	2,492
Total	11,992	12,703	11,651	12,667

Sources: World Bureau of Metal Statistics and others.
[1] Includes Yugoslavia but no other communist country. [2] Excludes Yugoslavia. [e] Estimated.

Table 5. Canadian primary aluminum smelter capacity, 1972

Smelter Location	Annual Capacity
	(short tons)
Aluminum Company of Canada, Limited	
Quebec	
Arvida	458,500
Isle-Maligne	130,000
Shawinigan	95,000
Beauharnois	51,500
British Columbia	
Kitimat	300,000
Total Alcan capacity	1,035,000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie-Comeau	175,000
Total Canadian capacity	1,210,000

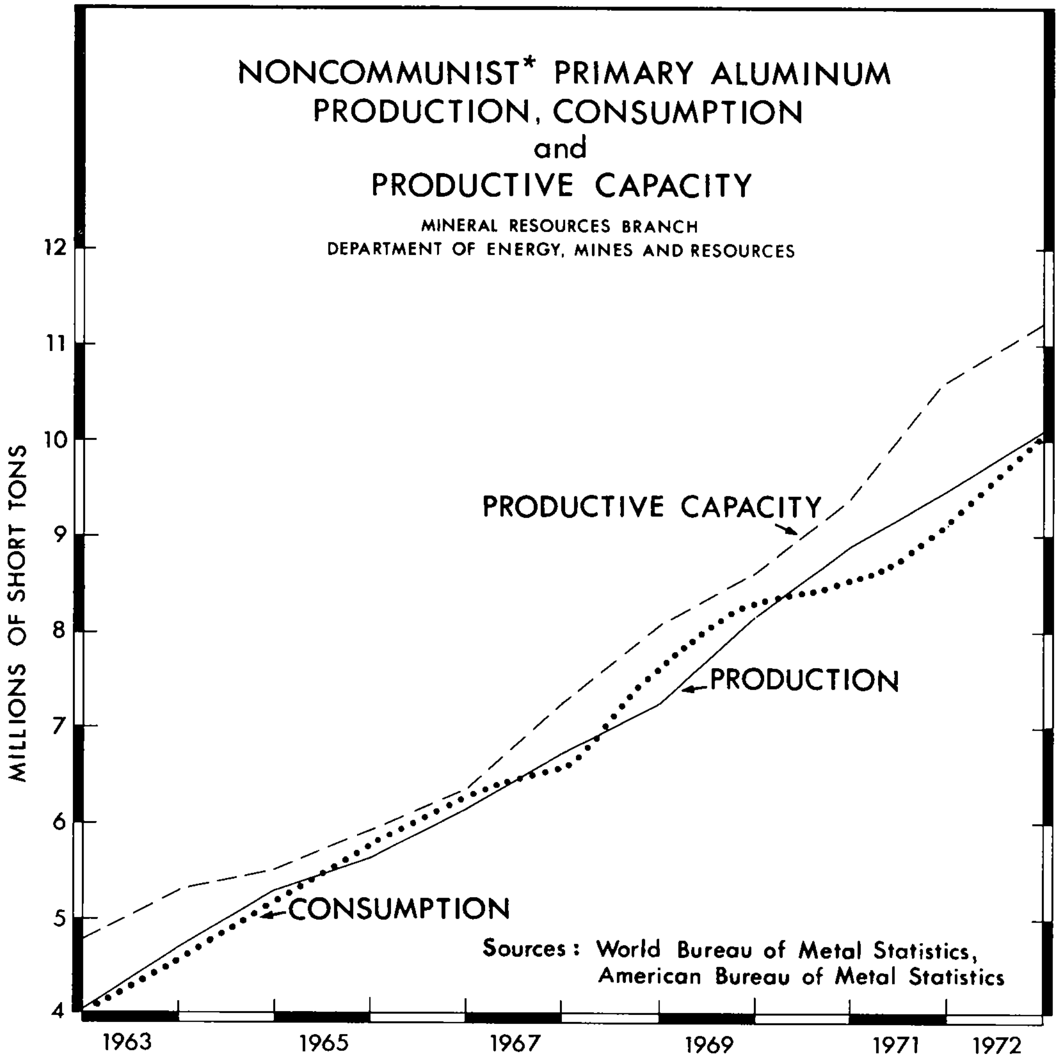
significantly to Alcoa's expansion. Other projects have suffered delays, such as the Comalco Limited refinery at Weipa and the Pacminex Pty. Ltd. bauxite-alumina complex, both in Australia, the Bintan bauxite-alumina project in Indonesia and Kibi in Ghana. Alcan, after cancelling its original plans in the Amazon Basin of Brazil, subsequently announced reactivation studies for this bauxite-alumina project, with the aid of Brazilian and possibly other interests.

Primary aluminum production throughout the world was 12,703,000 tons in 1972, some 6 per cent more than in 1971. Nevertheless, many producers continued to restrict their output and delayed expansion of production facilities. The result was a virtual balance between supply and demand and a halt to the accumulation of excess stocks. These stocks represented a serious financial burden to many producers and also caused depressed prices. The United States remained the largest producer, followed by Russia. Canada, which had been in third place for many years, was narrowly overtaken by Japan. Aluminum capacity expanded in noncommunist countries by some 500,000 tons in 1972, although only two new smelters began production in that year, compared with 13 in the previous year. Most expansions were limited to increasing operations at recently opened smelters or relatively small additions to existing facilities. Japan was a notable exception with a sizable expansion (see Table 7). A new entrant into the primary smelting industry will be Sumitomo Light Metal Company which has joined with Sumitomo Chemical Company to construct a 200,000-ton-a-year smelter in Sakata. Another is Furukawa Aluminum Company Ltd., which will build a 77,000-ton-a-year smelter in Fukui. Sumitomo Chemical Company, on its own, is constructing additional smelter capacity in Japan, as is Mitsubishi Chemical Industries and Showa Denko K.K. However, the Kobe Steel project and Nippon Light Metal Company's Niigata smelter expansion have been relegated to the background, whereas

Table 6. Estimated world production of bauxite in 1972

	Production (million short tons)
Australia	13.1
Jamaica	12.0
Surinam	6.2
Guyana	3.5
France	3.2
Greece	3.1
Republic of Guinea	2.6
United States	1.9
Other noncommunist countries[1]	9.0
Total noncommunist countries	54.6
Communist countries	7.3
World total	61.9

Source: United States Bureau of Mines, Commodity Data Summaries, January 1973.
[1] Production of Yugoslavia included.



* Includes Yugoslavia, which trades extensively with noncommunist countries

plans for Okinawa Aluminum Company's smelter have been abandoned. Other large facilities in the indefinite planning stage are the Asahan project in Indonesia, the Alcoa project in Greece and that of Comalco at Gladstone, Australia. Production at the new Lynemouth smelter of Alcan in Great Britain, which will have an annual capacity of 132,000 tons, has been severely limited by delays in starting up its power source. On the other hand, Anaconda Aluminum Company is rushing its new 120,000-ton-a-year smelter at Sebree, Kentucky to completion. Reynolds Metals Company is proceeding with construction of its smelter in Hamburg, West Germany. EFIM, an Italian state holding company, will start up its 125,000-ton-a-year smelter in Sardinia in 1973. Other additional smelting facilities are planned in Spain, Taiwan, India, Brazil, Argentina, and the Netherlands.

Noncommunist world consumption of primary aluminum in 1972 was 10,175,000 tons, a significant gain of about 9 ½ per cent above the previous year's consumption. Expanding demand in the United States was well maintained, whereas European and Japanese markets both exhibited considerable recovery. In Japan, 1972 consumption rose by 19 per cent over the previous year, compared with a 1971 increase of only 7 per cent. In Europe, consumption rose 8 per cent after a decline of 3 per cent in 1971.

Canadian exports of aluminum decreased markedly in 1972 compared with the previous year. This situation resulted partly from a loss of production during a labour strike at Canadian Reynolds and partly because of increased competition for markets. Canadian exports to the United States held up well, but those to traditional markets in Great Britain, Japan, and West Germany declined severely. Considerable new aluminum production capacity has been built in large consuming countries, United States, West Germany, Great Britain and Japan, all of which have been extensive importers of primary aluminum. Production facilities also have been built in countries such as Ghana, Greece, Surinam, Bahrain and New Zealand. The output of each of these countries is far beyond what is required for its domestic needs. Overcapacity in the industry has resulted and sales have been extremely competitive. The entry of Great Britain into the European Economic Community, with the at-

Table 7. Estimated increases in primary aluminium capacity in 1972[1]

	Company	Location	New Plant (N) or Addition (A)	Capacity Increase[2]
				(thousand tons)
Japan	Mitsubishi Chemical Industries Ltd.	Sakaide	A	50
	Mitsui Aluminum Co.	Omuta	A	41
	Nippon Light Metal Co.	Niigata	A	46
	(50% Alcan)	Tomakamai	A	20
Bahrain	Aluminium Bahrain	Alba	A	55
Yugoslavia	(state owned)	Sibenik	N	50
		Kidricero	A	3
New Zealand	New Zealand Aluminium Smelter Ltd. (Comalco, Showa Denko & Sumitomo Chemical)	Bluff	A	42
Britain	Alcan Aluminium (U.K.)	Lynemouth	N	33
Iran	Iranian Aluminium Co.	Arak	N	33
Iceland	Icelandic Aluminium Co. Ltd. (Alusuisse)	Straumsvik	A	33
India	Hindustan Aluminium Corp. Ltd. (27% Kaiser)	Renukoot	A	16
	Indian Aluminium Co. Ltd. (Alcan 65%)	Belgaum	A	6
	Madras Aluminium Co. Ltd. (27% Montecatini-Edison)	Mettur	A	6
Norway	Alnor Aluminium A/S (Martin Marietta & Norsk Hydro)	Karmoy	A	10
	Ardal ogg Sundal Verk (Alcan & Norwegian Govt.)	Ardal	A	5
	Mosal A/S (Elkem A/S & Alcoa)	Mosjoen	A	5
		Lista	A	5
	Sor-Norge Aluminium A/S (67% Alusuisse)	Husnes	A	2
Brazil	Alumina Minas Gerais (Alcan)	Arata	A	10
	Cia Brasiliera de Aluminio	Sorocaba	A	11
United States	Martin Marietta Aluminum	Goldendale, Wash.	A	9
	Ormet (Olin & Revere)	Hannibal, Ohio	A	10
West Germany	Giulini GmbH	Ludwigshafen	A	12
	Kaiser – Preussag	Voerde	A	5

Sources: OECD and others.

[1] Includes Yugoslavia but no other communist country. [2] For new plants, only initial achieved capacity is shown. Remainder of capacity will show as additions in subsequent years. Some new capacity was started near year-end and assignment to a particular year may cause some discrepancy.

tendant increase in tariffs on ingot imports, is another obstacle to Canadian trade. Canada is becoming increasingly dependent on the United States for its aluminum exports. Although Alcan received three orders from China in 1972 for a total of 15,000 tons of ingot, it is still too early to anticipate whether this outlet will evolve into an important new market. Currently the United States is proceeding with an extensive anti-dumping charge directed against aluminum imports from Canada. If this charge is sustained, additional import duties will be assessed and Canada's competitive position will be harmed. These trends and occurrences in export markets are extremely important to Canada's aluminum industry as domestic consumption is less than one third of primary aluminum production.

Technology

Aluminum Company of America has unveiled its new Alcoa smelting process which it believes is the future successor to the traditional Hall-Heroult method of smelting aluminum. Alcoa's process combines alumina with gaseous chlorine to form aluminum chloride. The aluminum chloride is then separated into molten aluminum and chlorine at relatively low temperatures, the chlorine being recycled. Advantages of the new process are several: it requires 30 per cent less power than today's most efficient plants; it can tolerate power interruptions and reductions without the risk of the furnace contents solidifying; there are no fluoride nor any other type of undesirable emissions as the process takes place in a closed system. However, it is unlikely that the new method can be proven for full-scale commercial application in less than 5 years.

Another technological innovation was electromagnetic ingot casting developed by the Russians and licensed to Kaiser Aluminum & Chemical Corporation and Reynolds Metals Company in the United States. The process eliminates the need for removal of impurities in the ingot's skin, known as scalping.

Two new methods of joining aluminum without the use of a flux have been developed. The Alcoa method makes use of an ultrasonically agitated solder bath in which the materials to be joined are dipped. General Electric Company utilizes a brazing method in which the presence of magnesium vapour at the joints breaks down the oxide film that normally covers an aluminum surface and facilitates flow of the brazing alloy. Both of these methods hold promise for increased use of aluminum in air conditioners, heat exchangers and automotive radiators.

In the raw materials field, the search for economical bauxite substitutes continues. In a joint venture, Earth Sciences Incorporated, National Steel Corporation and Southwire Aluminum Company are constructing a pilot plant near Golden, Colorado to produce alumina from alunite, utilizing a modified Bayer process.

Uses

Characteristics such as lightness combined with strength, pleasing appearance, corrosion resistance, conductivity and heat reflectivity provide many advantages favouring the use of aluminum. It may be cast, rolled, extruded and forged with ease compared with many of its competitive materials. In the United States, by far the world's largest market, the construction field continued to be the largest consumer in 1972, accounting for 27 per cent of shipments, according to the Aluminum Association. Transportation, another major user, was in second place with 18 per cent, followed by containers and packaging 15 per cent, electrical uses 13 per cent, consumer durables 9 per cent, and machinery and equipment 6 per cent. It might be noted that in many of the other main consuming countries transportation ranks first.

In the construction field in 1972, new housing remained buoyant in the United States but the level of nonresidential building did not keep pace. It is doubtful if the rapid increase in residential construction can be maintained in 1973, although the market for mobile homes is accelerating significantly, in contrast to an expected fall-off in conventional housing. The importance of housing construction to the aluminum industry is obvious when one considers that the average new conventional or mobile home in the United States contains about 1,000 pounds of aluminum. Transportation reflects very high manufacturing activity in trailers, semitrailers, trucks and buses. The increasing use of aluminum cans for beer and soft drinks continues to be a major growth factor, aided by public acceptance of the efforts of aluminum manufacturers, brewers and bottlers to recycle the used cans.

There are two fields which have prospects of greatly increased consumption of aluminum. One is automotive, where the average use of aluminum in a standard size 1973 model car manufactured in North America rose to a record 76 pounds. The need to reduce vehicle weight because of the addition of increased safety and pollution control devices is apparent. Thus aluminum bumper reinforcement bars as well as all-aluminum bumpers have become accepted, with future prospects for aluminum body panels. Housings for the much-heralded Wankel rotary engine should contain considerable quantities of aluminum. With the advent of better joining techniques, aluminum radiators are a distinct possibility. The other major field is cryogenic tanks for holding liquefied natural gas (LNG). There are extensive plans to ship this form of energy from overseas natural gas producers to areas experiencing an energy shortage, such as the United States, Europe and Japan. Aluminum is expected to be used in both the ships transporting LNG and for onshore storage vessels.

Outlook

A continuation of the current growth of aluminum consumption is forecast, with a gain of 8 to 10 per cent expected in the United States in 1973 and a similar gain anticipated for total noncommunist consumption. World output of aluminum will rise to meet this increased consumption and excess smelter capacity will decline. Canadian production should follow this rising trend in 1973 unless Alcan suffers a work stoppage during labour negotiations scheduled for this year. Sheet and plate will become in short supply in the United States and other fabricating countries, as rolling mills are operating near their limits and little additional capacity is under construction. The electric power shortages which occurred in Texas and the northwestern United States at the end of 1972, causing aluminum production cutbacks, are a foretaste of more serious energy shortages in that country. Aluminum production is expected to suffer. United States market prices for ingot probably reached their low point at the end of 1972 and, influenced by a supply shortage, are expected to rise considerably. Even the published price of 25 cents a pound may be expected to rise moderately in 1973. However, producers will not benefit from the full gain in price until the latter part of 1973, as many contracts for future delivery were negotiated at the low prices prevailing in 1972. In Europe and Japan, upward revaluation of currencies will cause prices to rise above United States levels, although no supply shortage is foreseen. Primary aluminum smelting industries in countries like Japan and West Germany, which have revalued their currencies upward, will become increasingly subject to competition from lower-priced imports. North American producers will experience low inventory levels whereas surplus stocks existing in other countries are expected to be significantly reduced in 1973. Disposal of the United States government stockpile of aluminum, even at accelerated rates, should be absorbed easily with no downward pressure on prices.

In energy-short countries like the United States and Japan, expansion of primary aluminum smelting facilities will become increasingly difficult, with environmental pollution another obstacle. For these reasons, as the present backlog of unused capacity declines, overexpansion is unlikely to take place to the same extent as in the early years of this decade. It is quite possible that some of Canada's unused resources of hydroelectric power will be the base for another round of expansion of our domestic aluminum smelting industry, if this is determined to be an opportune use of these resources.

Prices

The United States published price for 99.5 per cent primary aluminum ingot was 29 cents a pound at the beginning of 1972. In early May of that year, Kaiser Aluminum & Chemical Corporation reduced its list price to 25 cents a pound and this reduction was followed quickly by other producers. However because of competition due to oversupply, selling prices, reported as 20 ½ cents to 21 cents by *Metals Week* at the end of 1972, were significantly lower than published prices. In Canada the published price of 29 ½ cents a pound in effect throughout 1971 was withdrawn shortly after the Kaiser announcement, and subsequently no Canadian published price was in effect. Aside from ingot prices, which remained depressed, prices of some semifabricated items gained moderately. This gain was in response to rising demand, as producers attempted to recover some of their increased costs, particularly for labour.

Tariffs

Canada

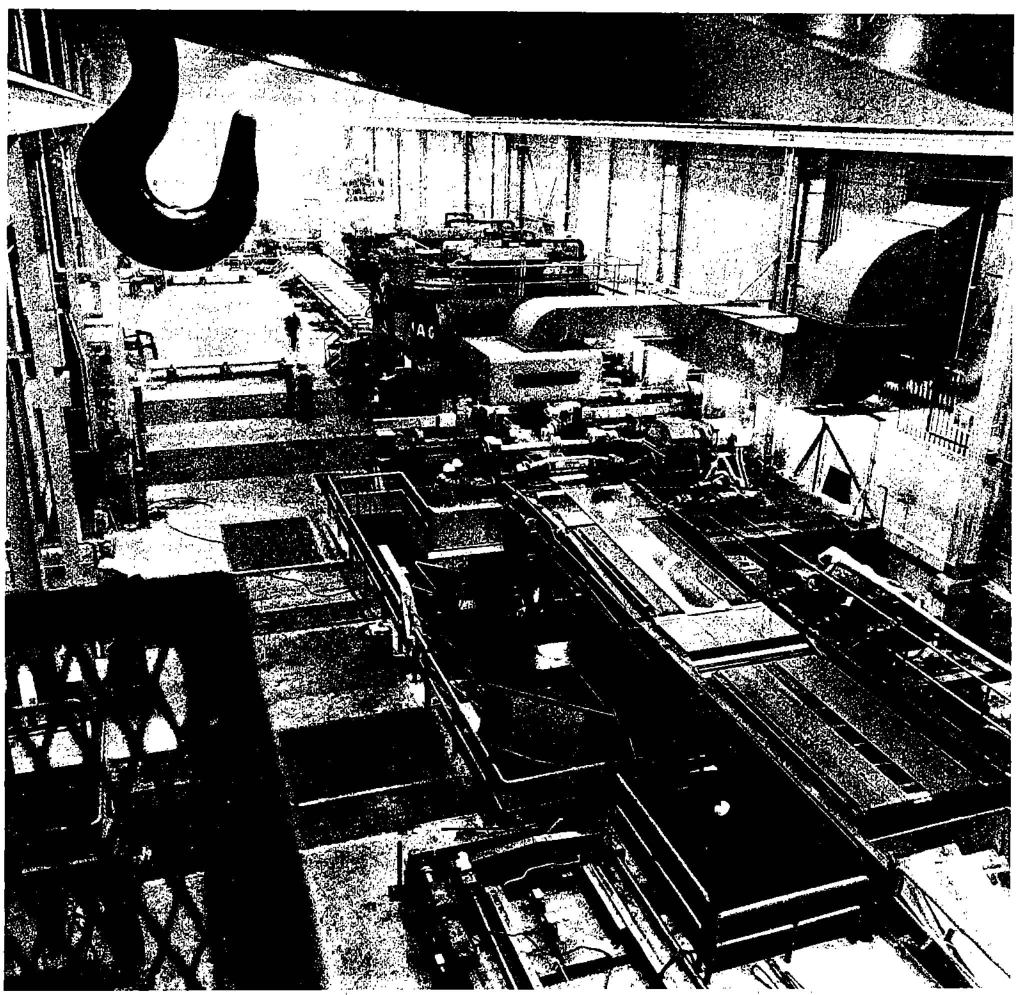
Item No.		British Preferential	Most Favoured Nation	General
32910-1	Bauxite	free	free	free
92820-1	Aluminum oxide and hydroxide; artificial corundum (This tariff includes alumina)	free	free	free
			(¢)	(¢)
35301-1	Aluminum pigs, ingots, blocks, notch bars, slabs, billets, blooms, and wire bars, per lb	free	1	5
35302-1	Aluminum bars, rods, plates, sheets, strips, circles, squares, discs and rectangles, per lb	free	2	7.5
			(%)	(%)
35303-1	Aluminum channels, beams, ties and other rolled, drawn or extruded sections and shapes	free	12½	30
35305-1	Aluminum pipes and tubes	free	12½	30
	Various tariffs are in effect on more advanced forms of aluminum			

United States

Item No.		On and After January 1 1971	1972
601.06	Bauxite	10¢ per long ton*	free
		(¢ per lb)	
417.12	Aluminum compounds: hydroxide and oxide (alumina)	0.15*	0.12*
618.01	Unwrought aluminum, in coils, uniform cross-section not greater than 0.375 inch	1.5	1.2
618.02	Unwrought aluminum, other, excluding alloys	1	1
618.04 618.06	Unwrought aluminum alloys, aluminum silicon and other aluminum alloys	1	1
618.10	Aluminum scrap (duty on scrap suspended until 30 June 1973)	0.9	0.7
	Various tariffs are in effect on more advanced fabricated forms of aluminum		

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.
*Declared free as of July 16, 1971 by Public Law 92-151.

Alcan's plant in Arvida, Quebec is the first in the aluminum industry to combine continuous casting of a wide slab in tandem with a rolling process. (Alcan Canada Products Ltd. photo).



Antimony

M. GAUVIN

Canada's antimony is produced as a byproduct of lead smelting operations, principally in the form of antimonial lead but also as antimonial dross and, in much smaller quantities, as high-purity antimony metal. The antimony content of primary antimonial lead produced in 1972 was 470,000 pounds, compared with 323,525 pounds in 1971.

Canadian requirements of antimony metal, antimony oxide and antimony salts are imported. Regulus (metal) import statistics were discontinued in 1964 but in earlier years the main suppliers were the People's Republic of China and Yugoslavia, which mine and refine antimony ores, and western European countries, which import antimony ores and concentrates and export refined metal and salts. Imports of antimony oxide in 1972 totalled 1,029,900 pounds, of which 75 per cent came from Britain, 10 per cent from the United States, and 15 per cent from the People's Republic of China.

Cominco Ltd., which operates a lead smelter and refinery at Trail, British Columbia, is the main producer of primary antimonial lead in Canada. Its antimonial lead has a variable antimony content up to 23 per cent, depending on the customers' requirements. The only other primary producer of antimonial lead is Brunswick Mining and Smelting Corporation Limited, Smelting Division, which operates a smelter at Belledune, New Brunswick. Secondary smelters recovered antimonial lead from scrap metal but no recent information is available concerning this production. In 1969 these smelters reclaimed 30,685 short tons* of antimonial lead from scrap compared with 26,815 tons in 1968.

Domestic sources and occurrences

Most of the antimonial lead produced at Trail is a byproduct of the lead concentrate obtained from ores of Cominco's Sullivan mine at Kimberley, British Columbia. Other sources are the lead-silver ores and concentrates shipped to Trail from other Cominco mines and from custom shippers. The lead bullion produced from the smelting of these ores and concentrates contains about 1 per cent antimony, which is recovered in anode residues from the electrolytic refining of the bullion and in furnace drosses produced during purification of the cathode lead. These residues and drosses are treated to yield antimonial-lead alloy to which refined lead may be added to produce marketable products of the required grade. At Belledune, the Brunswick Mining and Smelting plant produced an unspecified amount of antimonial dross in 1972.

Consolidated Durham Mines & Resources Limited is Canada's only antimony mine. It mines vein-type ore deposits containing stibnite (Sb_2S_3) at its Lake George property near Fredericton, New Brunswick. The company started production on a tuneup basis in December 1971, and the mill operated throughout 1972 except for three months when it was shut down in order to make necessary changes in mill design, implement a water pollution control system, and undertake additional shaft sinking and underground development. The mill produces concentrates averaging over 64 per cent antimony, which are shipped to Japan, Europe and the United States.

Several other Canadian occurrences or deposits of stibnite have been explored and partly developed, but results generally have been discouraging. The better known occurrences are in the Atlantic provinces, Quebec, British Columbia and the Yukon Territory. On the Wheaton district property of Yukon Antimony Corporation Ltd., development work, including an adit driven in previous years, has outlined a limited tonnage of antimony ore.

World review

World mine production of antimony in 1972, as estimated by the United States Bureau of Mines, totalled 77,100 tons, 6,940 tons more than in 1971. Antimony is produced from ores and as a smelter byproduct in about 25 countries with the major sources of ore being the Republic of South Africa, the People's Republic of China, Bolivia, U.S.S.R., Mexico, Turkey and Yugoslavia. Prior to 1935 China, which reputedly has over 50 per cent of the world's reserves, produced two thirds of the annual world output of antimony but during the Chinese-Japanese War the centre of production shifted to the Americas. The United States, Mexico and Bolivia were the leading world suppliers of antimony during and immediately after World War II. In the years following the Korean War, the Republic of South Africa, the People's Republic of China and Bolivia became the dominant suppliers of antimony.

*All tons are short tons of 2,000 pounds unless otherwise specified.

Table 1. Canada, antimony production, imports and consumption, 1971-72

	1971		1972p	
	(pounds)	($)	(pounds)	($)
Production				
Antimony content of antimonial lead alloys	323,525	243,614	470,000	290,000
Imports				
Antimony oxide				
Britain	428,000	332,000	777,300	451,000
People's Republic of China	77,600	39,000	154,500	73,000
United States	79,000	63,000	98,100	62,000
Belgium and Luxembourg	6,000	3,000	–	–
Total imports	590,600	437,000	1,029,900	586,000
Consumption				
Antimony regulus (metal) in production of:				
Antimony lead alloys	993,160	..	1,370,517	..
Babbitt	116,715	..	217,976	..
Solder	33,085	..	112,349	..
Type metal	129,771	..	119,893	..
Other commodities[1]	208,791	..	178,420	..
Total	1,481,522		1,999,155	

Source: Statistics Canada.
[1] Includes foil, bronze, lead-base alloys, drop shot and other minor commodities.
p Preliminary; – Nil; .. Not available.

Table 2. Antimony, Canadian production, imports and consumption, 1963-72

	Production,[1] All Forms	Imports Regulus	Consumption[2] Regulus
		(pounds)	
1963	1,601,253	1,036,235	975,627
1964	1,591,523	..	558,091
1965	1,301,787	..	659,637
1966	1,405,681	..	1,098,162
1967	1,267,686	..	1,190,179
1968	1,159,960	..	1,169,631
1969	820,122	..	1,305,742
1970	726,474	..	1,142,009
1971	323,525	..	1,481,522
1972p	470,000	..	1,999,155

Source: Statistics Canada.
[1] Antimony content of antimonial lead alloy. [2] Consumption of antimony regulus (metal), as reported by consumers. Does not include antimony in antimonial lead produced by Cominco Ltd.
p Preliminary; .. Not available.

In South Africa, Consolidated Murchison Limited operates the world's largest antimony mine in the vicinity of Gravelotte in northeast Transvaal. It has a mining and milling plant with a capacity of 660,000 tons a year of stibnite ore averaging 3 per cent antimony and is currently sinking a new shaft in the area. All its production of antimony concentrates is exported.

With Czechoslovakian backing, Bolivia is building a new antimony smelter scheduled for completion in 1975 and is seen emerging as a fully integrated antimony producer from mine to smelter. The smelter will have an annual capacity of 5,500 tons of metallic antimony and 1,100 tons of antimony alloys.

N L Industries, Inc. operates the world's largest antimony smelter for ores and concentrates at Laredo, Texas, where it produces antimony metal and oxide, mainly from imported Mexican, South African and Bolivian antimony ores and concentrates. The United States mine production of antimony in 1972 was 51 per cent below that of 1971 because a fire in May closed the Sunshine mine of Sunshine Mining Company, the major producer of antimony. The Sunshine mine resumed operations in the spring of 1973. Recovery of antimony in antimonial lead scrap is a major source of supply. This secondary supply represents a substantial portion, up to 60 per cent, of total antimony supply in the United States and other highly industrialized countries.

The antimony industry in 1972 experienced a more balanced supply-demand relationship, in contrast

Table 3. Canadian consumption of antimonial lead alloy[1] by end-use 1970-72

	1970	1971	1972
		(pounds)	
Batteries	1,283,478	1,791,469	..
Type metal	16,421	20,000	..
Babbitt	66,125	27,381	..
Solder	9,348	1,303	..
Other uses	25,030	16,532	..
Total	1,400,402	1,856,685	

Source: Statistics Canada.
1 Antimony content of primary and secondary antimonial lead alloys.
.. Not available.

Table 4. Canadian consumption of antimonial lead alloy,[1] 1963-72

	(pounds)		(pounds)
1963	2,688,157	1968	2,124,903
1964	2,506,454	1969	2,321,770
1965	2,775,241	1970	1,400,402
1966	2,593,733	1971	1,856,685
1967	2,496,032	1972	..

Source: Statistics Canada.
1 Antimony content of primary and secondary antimonial lead alloys.
.. Not available.

to 1971 which was characterized by an oversupply situation resulting from lack of consumer demand and from expanded free-world production brought on by high prices in the previous years. In 1972 prices were stable with a firming demand in the last half of the year which has continued into 1973. The antimony market is very sensitive to changes in supply and demand and indications are that the producers in various countries are considering building new facilities or expanding existing ones.

The United States was again the noncommunist world's largest consumer of antimony and continued to depend on foreign supplies for much of its requirements. Its consumer requirements in 1971 were about 20 per cent of noncommunist primary world supply and in 1972 it imported approximately 27 per cent of the world's primary supply. Antimony metal contained in the United States government stockpile totalled 46,676 tons as of December 31, 1972, down 71 tons from that at the beginning of the year and remaining at 115 per cent of the objective of the General Services Administration.

Table 5. World mine production of antimony, 1970-72

	1970	1971	1972[e]
		(short tons)	
Republic of South Africa	18,841	15,704	20,000
Bolivia	12,724	12,861	13,500
People's Republic of China[e]	13,000	13,000	*
U.S.S.R.[e]	7,400	7,600	*
Mexico	4,925	3,500	4,200
Turkey	3,053	3,100	*
Yugoslavia	2,200	2,900	3,200
Morocco	2,175	2,116	*
Italy	1,381	1,405	*
United States	1,130	1,025	500
Australia	833	1,267	*
Thailand	2,598	2,529	*
Czechoslovakia	660	660	*
Canada	363	162	235
Other countries	1,924	2,332	35,465
Total	73,207	70,161	77,100

Sources: For Canada, Statistics Canada. For other countries, U.S. Bureau of Mines *Minerals Yearbook*; U.S. Bureau of Mines, Commodity Data Summaries, January 1973, for 1972.
* Included in "Other countries".
[e] Estimated.

Uses

Antimony is used principally as an ingredient in many alloys and in the form of oxides and sulphides.

Antimony hardens and strengthens lead and inhibits chemical corrosion. The use of antimonial lead in storage batteries remains its major outlet but the antimony content in such batteries has been progressively reduced in recent years by technological developments from about 11-12 per cent to current levels which vary from 3 to 6 per cent of the antimonial lead contained. Antimonial lead alloys are also used for power transmission and communications equipment, printing metal, solder, ammunition, chemical pumps and pipes, tank linings, roofing sheets and antifriction bearings.

Antimony oxide, Sb_2O_3, usually produced directly from high-grade sulphide ore, is used extensively in plastics and in flameproofing compounds. Antimony trioxide or trichloride in an organic solvent has long been recognized as having significant flame-retardant properties and is now used extensively in carpets, rugs and carpet underlay. The trioxide is also a glass former and is sought for its ability to impart hardness and acid resistance to enamel coverings for such items as bathtubs, sinks, bowls and refrigerators. The pentasulphide, Sb_2S_5, is employed as a vulcanizing agent by the rubber industry and burning antimony sulphide creates a dense white smoke that is used in visual control, in sea markers and in visual signaling. It is valuable for paint formulation because of its high hiding power and because its various chemical compounds produce a wide range of pigments. High-purity metal is used by manufacturers of indium-antimony and aluminum-antimony intermetallic compounds as a semiconductor in transistors and rectifiers.

Outlook

The major end use of antimony is expected to continue to be as antimonial lead for storage batteries. As less developed countries become more industrialized and mechanized this use is expected to grow. The advent of a popular battery-powered electric vehicle could sharply increase this consumption. Attractive battery-powered electric cars and buses that have been test driven for the past two years in the United States average from 35 to 55 miles per charge depending on the type of driving done. However, the use of antimony in batteries is still threatened by the possibility of antimony being replaced by calcium.

The growing use of antimony oxide as a flame-retardant should more than offset any decline in some of the metal's historic uses or its substitution by other metals. In the United States regulations for flammability standards for children's sleepwear come into force in July 1973 and new flammability standards for motor vehicle interiors are to apply to the 1974 models of cars, trucks, buses and passenger carriers, all of which bodes well for antimony usage in flame retardants.

The world outlook for antimony appears favourable with a steady demand expected during the next few years. For the near future prices are expected to remain stable and the demand firm. The availability of antimony from the world's major producing countries will provide ample long-term supplies and should control excessive short-term fluctuations.

Prices

Prices remained steady throughout 1972. The United States domestic price of antimony as quoted in *Metals Week*, in bulk 99.5 per cent, fob Laredo, Texas, was 57 cents a pound during all of 1972.

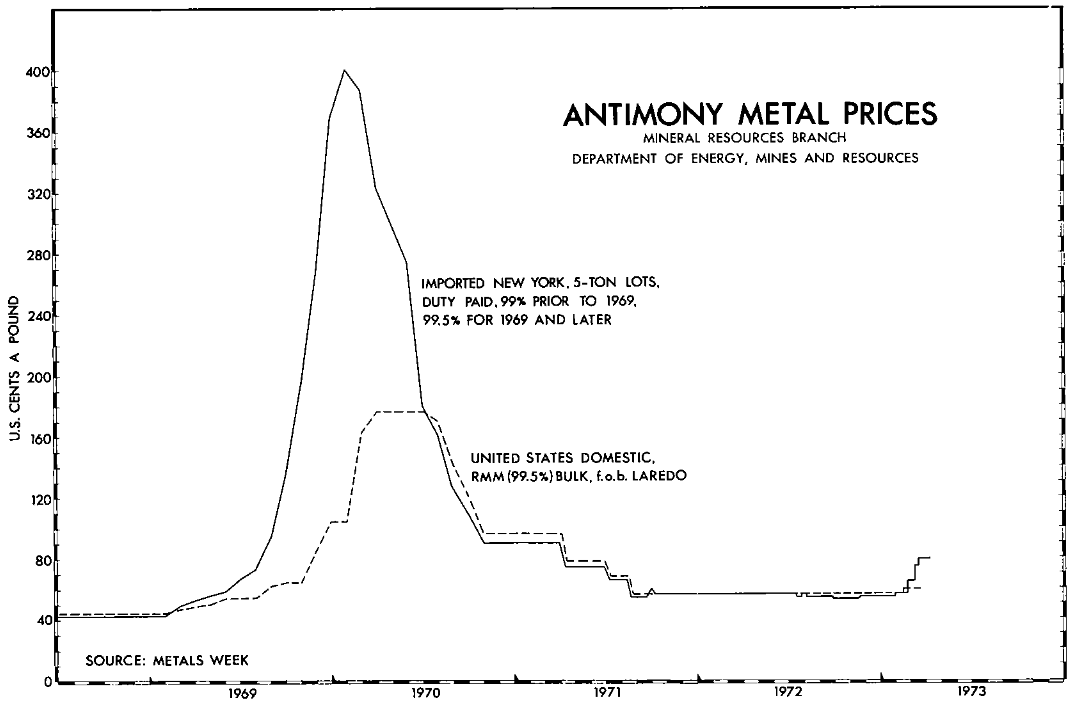
The United States price of imported antimony metal, as quoted in *Metals Week*, in 5-ton lots, 99.5-99.6 per cent, fob New York, duty paid, was 57 cents a pound from January 1 until July 14, 1972, when it dropped to 55 cents. From then until November 17 it varied between 57 cents and 53.5 cents and closed out the year at 55 cents.

Antimony lump ore prices, based on a 60 per cent antimony content as quoted in *Metals Week*, dropped from $8.64-$10 per short ton unit at the beginning of the year to $6.84-$7.84 on August 4 and then rose to $7.60-$8.60 at year-end.

Table 6. Industrial consumption of primary antimony in the United States, by class of material produced

Product	1970	1971	1972	Product	1970	1971	1972
	(short tons, antimony content)				(short tons, antimony content)		
Metal products				**Nonmetal products**			
Ammunition	102	67		Ammunition primers	27	23	
Antimonial lead	5,246	5,430		Fireworks	17	4	
Bearing metal and bearings	481	515		Flameproofing chemicals and compounds	1,710	1,524	
Cable covering	38	36		Ceramics and glass	1,820	1,840	
Castings	16	20		Pigments	610	592	
Collapsible tubes and foil	35	22		Plastics	1,667	1,810	
Sheet and pipe	77	74		Rubber products	519	525	
Solder	286	178		Other	993	768	
Type metal	220	177		Total	7,363	7,086	
Other	73	102					
Total	6,574	6,621		Grand total	13,937	13,707	

Source: United States Bureau of Mines, *Minerals Yearbook* Preprint 1971, and Mineral Industry Surveys.



Tariffs

Canada Item No.		Most Favoured Nation	United States Item No.		Most Favoured Nation
33000-1	Antimony, or regulus of, not ground, pulverized or otherwise manufactured	free	601.03	Antimony ore	free
			632.02	Antimony metal, unwrought, on and after Jan. 1, 1972	1¢ per lb
33502-1	Antimony oxides	12½%			

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), T.C. Publication 452.

Asbestos

G. O. VAGT

Canadian production (shipments) of asbestos fibre was 1,692,000 tons valued at $219.7 million in 1972, compared with 1,634,579 tons valued at $204.0 million in 1971. All of the Canadian production consists of chrysotile and 81 per cent of it comes from Quebec, over 6 per cent from British Columbia and a similar percentage from the Yukon, 4 per cent from Newfoundland and over 2 per cent from Ontario.

Exports of fibre represent 95 per cent of production, leaving 5 per cent for Canadian consumption. The United States continued as our major market, consuming 43 per cent of total asbestos fibre production. The major changes in trading during the year were with the United States and Britain: in 1972 fibre exports to the United States increased by 68,122 tons and exports to Britain decreased by 11,477 tons. Exports to Japan remained essentially the same. Exports of asbestos manufactured products decreased about 6 per cent from 1971, amounting to $5,366,000 in 1972. Work stoppages at the St. Lawrence River ports delayed shipments of fibre in May-June and in Vancouver shipments were delayed in August.

Canadian developments

The major developments at the producing mines are summarized in Table 2. In Quebec, near Deception Bay, Ungava, production commenced at the new Asbestos Hill mine owned by Asbestos Corporation Limited and a quantity of concentrate was shipped to the finishing mill in West Germany. Full productive capacity of 100,000 tons of fibre, mainly groups 4 and 5, is anticipated by 1974.

Canadian Johns-Manville Company, Limited completed about 75 per cent of its plant expansion and relocation program as part of a $75 million project at the Jeffrey mine and mill. A constant annual output of a minimum 600,000 tons of fibre will be maintained and the expanded facilities will allow recovery of grade 6D fibre from pre-1930 tailings.

Bell Asbestos Mines, Ltd. continued work on a long-range modernization program which may result in increased productive capacity. A production-sized shaft has been sunk to a depth of 1,450 feet near the open pit; underground work proceeded from the shaft with a view to large-scale underground mining.

In Ontario, total production by Hedman Mines Limited and Johns-Manville Mining and Trading Limited's Reeves mine decreased 19 per cent from 1971. This was partly the result of a one-month suspension of operations at the Reeves mine because of poor market conditions coupled with a large stockpile of available fibre.

Advocate Mines Limited, Newfoundland's only asbestos producer, maintained fibre shipments at the same level as the previous year.

In British Columbia, Cassiar Asbestos Corporation Limited, Cassiar, shipped over 100,000 tons of fibre following its recently completed mill expansion to a capacity of 120,000 tons of fibre a year. Approximately 10,000 tons of grade AZ, equivalent to group 6 fibre in Quebec, was produced. Recent drilling confirmed that there are sufficient reserves for at least another 20 years of mining.

In the Yukon Territory, over 100,000 tons of fibre were also shipped from Cassiar's Clinton Creek mine. Included in this was a new grade, CZ, which was introduced to the market.

Prospective producers

United Asbestos Corporation Limited and Allied Mining Corporation propose to bring into production the asbestos property owned by Allied in Midlothian Township, 43 miles south of Timmins, Ont. Drilling has indicated 31 million tons of open pit reserves averaging 9 per cent fibre content in grades 5, 6 and 7. Recent production objectives were to produce 100,000 tons of fibre a year utilizing a 3,000-tpd plant.

Abitibi Asbestos Mining Company Limited reported that work on a pilot plant commenced at its property in Maizerets Township, 52 miles north of Amos, Que. Proven ore reserves were about 100 million tons with a 4 per cent fibre content in groups 4, 5 and 6. Earlier plans were to mine by open pit and to recover approximately 155,000 tons of fibre a year.

McAdam Mining Corporation Limited's property, about 20 miles east of Chibougamau, Que., and under working option to Rio Tinto Canadian Exploration Limited, was being evaluated by an underground work program. Work will concentrate on the "C" zone calculated to contain a geological reserve of 105,000,000 tons of material grading 3.92 per cent fibre to a depth of 700 feet. Bulk samples for processing will be taken to the Quebec government pilot plant at Quebec City. Three other zones on the property consist of total drill-indicated reserves of

Table 1. Canada, asbestos production and trade, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
By type				
Crude, groups 1, 2 and other milled	2,029	1,451,128	..	..
Group 3, spinning	34,491	13,632,198	..	..
Group 4, shingle	447,349	89,772,274	..	..
Group 5, paper	271,401	42,105,722	..	..
Group 6, stucco	303,565	29,033,764	..	..
Group 7, refuse	574,193	27,967,272	..	..
Group 8, sand	1,551	36,886	..	..
Total	1,634,579	203,999,244[1]	1,692,000	219,700,000[1]
By province				
Quebec	1,342,260	155,987,089	1,374,000	165,400,000
British Columbia	87,118	17,800,406	108,000	22,700,000
Yukon	91,969	12,374,380	104,000	14,200,000
Newfoundland	69,218	12,497,626	69,000	13,000,000
Ontario	44,014	5,339,743	37,000	4,400,000
Total	1,634,579	203,999,244[1]	1,692,000	219,700,000[1]
Exports				
Crude				
United States	45	44,000	17	15,000
Japan	49	40,000	17	14,000
Italy	9	16,000	14	15,000
France	2	3,000	7	6,000
West Germany	10	10,000	–	–
Total	115	113,000	55	50,000
Milled fibre (groups 3, 4 and 5)				
United States	207,954	45,723,000	211,100	47,148,000
Britain	62,081	14,397,000	59,801	13,984,000
West Germany	56,878	12,345,000	68,967	13,812,000
France	53,812	11,524,000	42,246	9,365,000
Australia	41,799	7,872,000	43,265	8,766,000
Japan	35,086	6,607,000	36,318	6,573,000
Spain	24,127	5,016,000	28,031	6,090,000
India	17,198	4,035,000	24,946	5,927,000
Belgium-Luxembourg	29,575	6,789,000	24,631	5,713,000
Mexico	22,174	4,955,000	21,318	4,870,000
Other countries	227,481	47,338,000	207,093	44,392,000
Total	778,165	166,601,000	767,716	166,640,000
Shorts (groups 6, 7, 8, 9)				
United States	455,479	31,045,000	503,552	35,499,000
Japan	74,414	6,904,000	75,138	6,841,000
South Korea	21,645	2,314,000	27,522	3,154,000
Britain	48,377	3,263,000	39,180	2,422,000
West Germany	33,382	2,324,000	28,639	2,057,000
France	24,654	1,493,000	25,735	1,549,000
Belgium-Luxembourg	17,204	1,433,000	16,727	1,424,000
Portugal	1,453	171,000	11,872	1,255,000
Netherlands	11,951	853,000	15,436	1,214,000
Argentina	8,565	664,000	8,844	678,000
Other countries	97,019	9,065,000	78,240	7,029,000
Total	794,143	59,529,000	830,885	63,122,000
Grand total, crude, milled fibres and shorts	1,572,423	226,243,000	1,598,656	229,812,000

Table 1 (concl'd)

	1971	1972^p
	($)	($)
Exports (cont.)		
Manufactured products		
Brake linings and clutch facings		
United States	552,000	453,000
Guatemala	61,000	63,000
Ecuador	48,000	43,000
Lebanon	51,000	40,000
Kuwait	–	37,000
Syria	21,000	28,000
Thailand	12,000	25,000
Greece	11,000	24,000
El Salvador	13,000	21,000
Other countries	188,000	113,000
Total	957,000	847,000
Asbestos and asbestos cement building materials		
United States	1,614,000	1,527,000
Netherlands	210,000	151,000
Britain	21,000	141,000
Australia	170,000	117,000
Switzerland	3,000	35,000
Venezuela	24,000	33,000
Israel	–	32,000
Indonesia	–	24,000
Other countries	301,000	93,000
Total	2,343,000	2,153,000
Asbestos basic products, nes		
United States	2,174,000	2,193,000
Switzerland	90,000	33,000
France	25,000	22,000
Netherlands	23,000	18,000
Britain	5,000	14,000
India	8,000	11,000
West Germany	1,000	10,000
Other countries	114,000	65,000
Total	2,440,000	2,366,000
Total exports, asbestos manufactured	5,740,000	5,366,000
Imports		
Asbestos, unmanufactured	1,294,000	1,291,000
	(6,599st)	(6,561st)
Asbestos manufactured		
Cloth, dryer felts, sheets, woven or felted	1,078,000	1,115,000
Packing	983,000	1,130,000
Brake linings	4,772,000	4,920,000
Clutch facings	363,000	644,000
Asbestos cement shingles and siding	258,000	160,000
Board and sheets	947,000	842,000
Asbestos and asbestos cement building materials, nes	3,656,000	3,846,000
Asbestos and asbestos cement basic products, nes	2,450,000	1,918,000
Total asbestos, manufactured	14,507,000	14,575,000
Total asbestos, unmanufactured and manufactured	15,801,000	15,866,000

Source: Statistics Canada.
[1] Does not include value of containers.
^{p}Preliminary; – Nil; nes Not elsewhere specified.

86,371,000 tons with a fibre content of 3.55 per cent.

Pathfinder Resources Ltd. and Pan Ocean Oil Corporation are negotiating an agreement that may result in the development of Pathfinder's Lili asbestos property, 80 miles east of Montreal and 2 1/2 miles from the Canadian Johns-Manville mine. Recent drilling has indicated over 45 million tons of ore in three zones. Earlier tonnage and grade estimates were 18.6 million tons grading 4.68 per cent asbestos fibre and 20.0 million tons grading 3.87 per cent.

World developments

In Australia, Woodsreef Mines Limited, 58.5 per cent owned by Woodsreef Minerals Ltd., of Canada, commenced production early in 1972. At capacity the plant has a rated output of 70,000 tons of asbestos fibre a year consisting of groups 4 to 7. Plant expansions are planned to allow a doubling of rated annual capacity in 2-3 years. A total of 200,000 tons of fibre is contracted to Japan over the first five years of operation.

Compania Nacional de Asbestos, a government-owned company, proceeded with construction of a mill in the State of Tamaulipus, Mexico. When full production capacity is reached the plant may serve to decrease Mexican imports from Canada. Ore reserves were last reported at about 6 million tons with 10 per cent recoverable fibre. Evaluation work at the Oxaca deposit, near Cuicatlan, was continued by Industrias Penoles, S.A. This deposit, which was partly owned by Freeport Minerals Company, has drill-indicated reserves of about 110 million tons of medium to short fibre-bearing material.

Table 2. Canadian asbestos producers, 1972

Company	Mine Location	Mill Capacity	Remarks
		(st ore/day)	
Advocate Mines Limited	Baie Verte, Nfld.	7,500	Open pit.
Carey-Canadian Mines Ltd.	East Broughton, Que.	5,500	Open pit, plant expansion completed.
Asbestos Corporation Limited			World's major independent asbestos producer.
Asbestos Hill mine	Asbestos Hill, Que.	6,000	Started production. Annual capacity is 300,000 tons of concentrate for final processing to 100,000 tons of fibre at Nordenham, W. Germany.
British Canadian mine	Black Lake, Que.	12,400	Open pit, two milling plants.
King Beaver mine	Thetford Mines, Que.	12,000	Underground and open pit.
Normandie mine	Black Lake, Que.	7,500	Open pit, development of Penhale orebody deferred.
Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	3,000	Underground.
National Asbestos Mines Limited	Thetford Mines, Que.	3,500	Open pit.
Lake Asbestos of Quebec, Ltd.	Black Lake, Que,	9,000	Open pit. Mineable reserves increased about 45 million tons by purchase of additional mining rights.
Canadian Johns-Manville Company, Limited			Western world's largest known asbestos deposit.
Jeffrey mine	Asbestos, Que.	33,000	Open pit. Mine and mill expansion under way to maintain annual output at a minimum of 600,000 tons of fibre.
Hedman Mines Limited	Matheson, Ont.	300	Open pit. The plant is designed to turn out only group 7 fibre.
Johns-Manville Mining and Trading Limited			
Reeves mine	Timmins, Ont.	5,000	Open pit.
Cassiar Asbestos Corporation Limited			
Cassiar mine	Cassiar, B.C.	3,300	Open pit. Mill expansion completed. New grade AZ (group 6) introduced.
Clinton mine	Clinton Creek, Yukon	4,000	Open pit. New grade CZ introduced.

In Colombia, Nicolet Industries Incorporated (70%) along with a Colombian partner (30%) continued evaluation of the Las Brisas deposit at Campamento in the Province of Antioquia. An annual production of about 30,000 tons of fibre is expected by 1974 if plans proceed as expected. Sample tests indicated that 35-40 per cent was group 4, up to 40 per cent group 5 and the remainder group 6. It is expected that Colombia will export about 50 per cent of this production.

In Brazil, Mineracao de Amianto S.A. was increasing production at its new Cana Brava mine Uruacu, in the state of Goias. Production from this mine may be over 30,000 tons a year in 1972. Metas e Bases (Goals and Bases) a government program, was investing $9.2 million in an asbestos mining project. An annual production of about 25,000 tons of fibre is the goal for 1973.

The Hellenic Industrial Development Bank, S.A., a government-related bank in Greece, basically approved a $30 million asbestos-mining project proposed by Cerro Corporation. The deposit is situated near Kozani, in northern Greece. The estimated initial annual capacity of the plant in 1974 will be approximately 45,000 tons of fibre with allowances for production to be staged to 100,000 tons a year.

World production and major markets

Chrysotile asbestos represents about 90 per cent of the approximately four million tons of annual world asbestos production. The two major producers of chrysotile are Canada and the U.S.S.R. Russian production in 1972 is estimated at approximately 1.2 million short tons (excludes about one million tons of very low-grade short fibre) compared with Canadian production of over 1.6 million tons. South Africa is

Table 3. Canada, asbestos production and exports, 1963-72

	Crude	Milled	Shorts	Total
		(short tons)		
Production[1]				
1963	217	579,085	696,228	1,275,530
1964	236	664,284	755,331	1,419,851
1965	163	659,598	728,451	1,388,212
1966	215	735,972	752,868	1,489,055
1967	288	705,295	746,521	1,452,104
1968	290	777,006	818,655	1,595,951
1969	7,017	687,924	916,227	1,611,168
1970	7,252	737,037	917,355	1,661,644
1971	2,029	753,241	879,309	1,634,579
1972^p	..	..	..	1,692,000
Exports				
1963	195	555,419	650,811	1,206,425
1964	214	630,515	702,747	1,333,476
1965	123	630,777	688,504	1,319,404
1966	172	732,585	713,405	1,446,162
1967	229	653,280	688,535	1,342,044
1968	202	723,136	736,330	1,459,668
1969	135	778,641	785,986	1,564,762
1970	101	824,324	738,007	1,562,432
1971	115	778,165	794,143	1,572,423
1972^p	55	767,716	830,885	1,598,656

Source: Statistics Canada.
[1]Producers' shipments.
^{p}Preliminary; .. Not available.

unique in that it is the only source of amosite in the world and the most important producer of crocidolite. Asbestos production for the first half of 1972 totalled 172,000 tons comprising 49 per cent crocidolite, 33 per cent amosite and 18 per cent chrysotile. The two major producers of anthophyllite are Finland and the United States.

World production of asbestos in 1972, based on USBM figures, was estimated at 4.03 million tons compared with a revised 1971 total of 3.95 million tons.

Total output by country did not appreciably change. As a percentage of world production the following 1971 figures apply: Canada, 41.5; U.S.S.R., 32.0; Republic of South Africa, 8.9; China, 3.5; Italy, 3.6; U.S.A., 3.4; Rhodesia, 2.6 and others, 4.5. Estimated 1971 world consumption of asbestos, excluding Russia and China remained at the 1970 level of over 2.9 million tons. The developing countries are becoming important consumers when considered as a whole, although individual consumption is small.

Canada exports more than 90 per cent of its production to over 70 countries; the United States is our major market, followed by Japan, Britain, West Germany and France. These countries receive about 70 per cent of Canadian exports, which total approximately 1.57 million tpy. Most of the production of the U.S.S.R. is consumed internally although exports now approaching 400,000 tpy are shipped to eastern Europe, France, Japan and West Germany. South Africa exports to countries throughout the world and its major customers are Japan, Britain, Spain, Italy and West Germany.

Fibre groups, uses and technology

To evaluate the quality of asbestos fibre there are five basic properties which must be considered: fibre length distribution, fibre bundle diameter distribution, harshness, tensile strength and surface activity. Other properties governing quality would be iron content, colour and dust content. The major standard on a length basis is that developed by the industry in Quebec, whereby asbestos is classified and priced by groups from the longest fibre corresponding to No. 1, to the shortest, No. 9. Because there are more than 3,000 uses for asbestos, it is more appropriate to classify the groups in categories and describe the major purposes the fibres serve rather than list the products in which they are used.

Long fibres. Crudes No. 1 and 2 and group 3 – Textile industry, electrical insulation, as a filtration medium, and reinforcing fillers in asbestos-cement products where great strength is required.

Medium-length fibres. Groups 4, 5, 6 – Reinforcing fillers in asbestos-cement products, friction materials such as brake linings and clutch facings, paper, pipe coverings, insulating mass in sprayed insulations.

Short fibres. Groups 7, 8, 9 – Reinforcing fillers in plastics, flooring tile, asphalt, and in paints and oil well muds.

Asbestos cement building materials and asbestos cement pipe together consume an estimated 70 per cent of world production. The domestic consumption of the United States differs, based on a survey done for a member of the Asbestos Information Association, North America. This survey indicated a consumption breakdown as follows: asbestos cement pipe and building products, 25 per cent; floor tile, 18 per cent; felts and papers, 14 per cent; friction products, 10 per cent; textiles, 3 per cent; packing and gaskets, 3 per cent; sprayed insulation, 2 per cent; and miscellaneous, 25 per cent.

A process for reusing a waste material that takes the effluent from a paper mill and converts it into a substitute for asbestos building board was patented by Plastic Research Laboratories, Tideswell, Derbyshire, England, part of the Spey Investments Group. Technological progress suggests that synthetic asbestos or asbestiform fibres will not be competitive for at least several years.

The U.S. Department of Labour issued the first nationwide standards for exposure to asbestos dust in recognition that airborne asbestos fibres may present a health hazard to workers and in certain instances to the public.

Outlook

The outlook for Canada's production of asbestos in 1973 is good, based on continued growth of consumption by the construction industry in North America and on predicted expansion of the economies in western Europe and Japan. Industry representatives disagree on the future rate of consumption growth in existing world markets. If production and consumption growth rates fall significantly below the previous 5–7 year rate of about 4 per cent, markets obviously will be restricted at the projected rate of new production. However, an average annual growth rate of 4.5 per cent is reasonable if consumption rates continue upward in the developing countries and in some key western European markets. The higher projected growth rate could mean that approximately 600,000 tons of new production would be required by 1975–76 for world markets or 1.3 million tons by 1980.

A review of the planned or feasible plant expansions by major Canadian producers suggests that 200,000 short tons of new fibre production is feasible by 1975. This approximate figure includes the higher output that Cassiar is expected to have resulting from plant expansions completed earlier and the annual production of 100,000 tons that Asbestos Corporation Limited plans to market from the Asbestos Hill mine. It does not include possible increased production by Bell Asbestos Mines, Ltd. following the long-range modernization plan. A review of possible new fibre output by prospective producers in Canada suggests that over 350,000 extra tons of fibre may be available by 1976–77. World consumption must continue to expand at a healthy rate to absorb this projected output, particularly if other asbestos mining projects in the world fully materialize.

Improving demand for fibre groups 4, 5 and 6, utilized in the construction materials industry, is expected to continue in the medium and longer term. The use of group 7 fibre, primarily as a filler in floor tiles and insulating wallboard, is also expected to continue at a good growth rate. Escalating costs in all segments of the industry may provide further impetus for the use of substitute materials in the generally very competitive construction materials market.

In highly developed countries such as the United States and Britain, where large quantities of fibre are already used in construction materials, growth rates will probably be slow, partly because of modifying effects from the irregular nature of the construction cycle. In fact, the estimated apparent consumption of 811,000 tons of fibre in the United States in 1972 was lower than in 1968, when 817,000 tons were consumed. Production in the U.S.S.R. is expected to continue its upward trend to satisfy domestic requirements. Exports are not expected to increase greatly in the short term except where specific trade agreements are concerned.

The outlook in the health and environmental field is uncertain, although significant progress has been achieved in establishing a trend toward lower threshold limits for dust concentrations in the air of mills and factories in which asbestos fibre is processed. The asbestos industry in Canada plans to spend about $20 million between 1970 and 1975 to ensure continuing and better environmental control.

Prices

Cassiar Asbestos Corporation Limited announced price increases ranging from 3 to 5 per cent at the end of 1972.

Canadian asbestos prices quoted in Asbestos

	July 1, 1971
Quebec, fob mines	($ per short ton)
Crude No. 1	1,615
Crude No. 2	875
Group	
No. 3 (spinning fibre)	412–675
No. 4 (asbestos-cement fibre)	227–383
No. 5 (paper fibre)	164–195
No. 6 (waste, stucco, plaster)	120
No. 7 (refuse, shorts)	52–100
	Jan. 1, 1973
Cassiar, fob North Vancouver B.C.	
Canadian group	
No. 3 (nonferrous spinning fibre)	
AAA grade	895
AA grade	711
A grade	541
*No. 4 AC grade (asbestos cement) (single fibre)	
No. 4 AK grade	276
No. 4 CP grade	261
No. 4 AS grade	240
No. 4 CT grade	235
No. 5 AX grade	219
No. 5 CY grade	155
No. 5 AY grade	155
No. 6 AZ grade	126
No. 6 CZ grade	126

*A grades from Cassiar mine. C grades from Clinton mine.

Tariffs

Canada Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
31210-1	Asbestos, crude	free	free	25
31215-1	Asbestos, yarns, wholly or in part of asbestos, for use in manufacture of clutch facings and brake linings	7½	7½	25
31225-1	Asbestos felt, rubber impregnated for use in mcf floor coverings	free	free	25
31200-1	Asbestos, in any form other than crude, and all manufactures thereof, nop	12½	12½	25
31205-1	Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, nop	free	12½	25
31220-1	Asbestos woven fabric, wholly or in part of asbestos for use in manufacture of clutch facings and brake linings	12½	12½	30

United States

Item No.				
518.11	Asbestos, not manufactured, crude, fibres, stucco, sand and refuse containing not more than 15 per cent by weight of foreign matter	free		
		On and After January 1		
		1970	1971	1972
		(%)	(%)	(%)
518.21	Asbestos, yarn, slivers, rovings, wick, rope cord, cloth, tape and tubing	5.5	4.5	4
518.51	Asbestos articles not specifically provided for	6	5	4.5
	Articles in part of asbestos and hydraulic cement	(¢ per lb)	(¢ per lb)	(¢ per lb)
518.41	Pipes and tubes and fittings thereof	0.2	0.18	0.15
518.44	Other	0.15	0.1	0.1

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa, Tariff Schedule of the United States, Annotated (1972) TC Publication 452.
nop Not otherwise provided for.

Barite and Celestite

G.O. VAGT

Output of barite in Canada declined in 1972 because of decreased output from Nova Scotia. Total production was an estimated 73,000 tons, 47,765 tons less than in 1971. Exports in 1972 were reduced by 53,691 tons. Imports of barium carbonate in 1972 increased by 120 tons to 3,872 tons valued at $463,000.

Barite ($BaSO_4$) is of value mainly because of its weight (specific gravity 4.5) and chemical inertness. Its dominant use is as a weighting agent in drilling muds when drilling oil and gas wells. The weight factor in the drilling mud is required to counteract high oil and gas pressures in the substrata.

Barite deposits are widespread throughout the world and it is mined in many countries, principally the United States, followed by West Germany, U.S.S.R. and Mexico. Canada is eleventh in world production and about 25 per cent of the output is exported, mainly as crude barite, to grinding plants in the United States.

Production and occurrences in Canada

Barite is found in a variety of geological environments: as the principal mineral in veins along with fluorite, calcite and quartz; as a gangue mineral in some lead-zinc-silver deposits; and as irregular replacement deposits in sedimentary rocks. Pure barite is white and is most common in veins; impure barite may be near-white, grey, brown and reddish. Barite was produced only in Nova Scotia and British Columbia in 1972.

Production difficulties continued at the Walton, N.S. mine, operated by Dresser Minerals Division of Dresser Industries, Inc. Attempts have been made to rehabilitate the Walton mine, flooded in October 1971, although there are formidable problems. Underground diamond drilling is being done to further investigate the source of mud and water inflows. Prior to flooding, the barite ore was mined from a large replacement deposit by a block-caving method and hoisted through the same shaft as lead-zinc sulphide ore mined in conjunction with the barite. At present, production at Walton is sustained by ore drawn from low-grade stockpiles, waste dumps and the tailings pond.

Most of the production was ground and transferred to an affiliated company for use in offshore oil drilling in eastern Canada. The remainder was shipped in crude form to southwestern United States.

There were two barite producers in British Columbia in 1972. Baroid of Canada, Ltd., recovered barite from tailings at an abandoned lead-zinc mine near Spillimacheen, south of Golden, the tailings were fed as a slurry to separation tables and the barite concentrate dewatered and shipped by rail for further processing in a grinding plant at Onoway, Alberta. Mountain Minerals Limited mined barite underground from vein deposits near Parson and Brisco in the eastern part of the province, and recovered crude barite from the tailings at the Mineral King mine near Invermere. The crude barite was shipped to the company's plant at Lethbridge, Alberta, for grinding.

In Ontario, Extender Minerals of Canada Limited, a subsidiary of L. V. Lomas Limited, continued construction of a new mill building to replace the partly rehabilitated mill previously destroyed by fire. This crushing and milling plant site, located in Powell Township near Ryan Lake, about four miles northwest of Matachewan, was formerly owned by Geo-Pax Mines Limited.

Extender Minerals plans to mine barite veins situated on the shore of Mistinikon Lake, 6 miles southwest of Matachewan. There was no production in 1972.

There are many occurrences of barite across Canada. Of note are occurrences in Newfoundland, at Buchans; in Nova Scotia, east of Lake Ainslie on Cape Breton Island, and near Brookfield on the mainland; in northern Ontario, in Yarrow, Penhorwood and Langmuir townships, and on McKellar Island in Lake Superior; and in northern British Columbia, at Mile 397, and north of Mile 548 on the Alaska Highway.

The Lake Ainslie deposit on Cape Breton Island is reported to contain 3 million tons of ore grading 44 per cent barite and 17 per cent fluorspar.

Uses, consumption and trade

The dominant use for barite is as a weighting agent in oil and gas well drilling muds where its specific gravity assists in counteracting high pressure in oil and gas reservoirs. Principal specifications are usually a minimum specific gravity of 4.25, a particle size of at least 90 per cent minus 325 mesh, and a maximum of 0.1 per cent water-soluble solids.

Table 1. Canada barite production, trade and consumption, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Production (mine shipments)	120,765	1,060,543	73,000	650,000
Imports				
United States	11,280	531,000	21,803	828,000
People's Republic of China	–	–	55	1,000
West Germany	52	3,000	–	–
Total	11,332	534,000	21,858	829,000
Exports				
United States	70,767	636,000	20,188	231,000
Venezuela	3,112	26,000	–	–
Total	73,879	662,000	20,188	231,000
	1970	1971		
Consumption (available data)[1]	(short tons)			
Well drilling	48,265^e	47,701^e		
Paints and varnish	2,046	2,397		
Glass and glass products[2]	4,502	5,110		
Rubber goods	253	249		
Other[3]	134	743		
Total	55,200^r	58,200^e		

Source: Statistics Canada.
[1] Available data reported by consumers; breakdown by Mineral Resources Branch.
[2] Includes glass fibre and glass wool. [3] Includes miscellaneous chemicals, cleansers, detergents and miscellaneous products.
^p Preliminary; – Nil; ^e Estimated by Mineral Resources Branch; ^r Revised.

No data is available on Canadian barite consumption in 1972; revised data based on apparent consumption in 1971 indicated domestic barite consumption of 74,700 tons. Approximately 90 per cent of this is considered to be utilized in drilling muds.

Barite is used in paint as a special filler or 'extender pigment'. This is a vital constituent that provides bulk, improves consistency of texture, surface characteristics and application properties, and controls prime pigment settling and viscosity of paints. Specifications for barite in the paint industry are about 95 per cent $BaSO_4$, particle size at least minus 200 mesh, and a high degree of whiteness or light reflectance.

The glass industry uses barite to increase the workability, act as a flux, assist decolouration and increase the brilliance or lustre of the glass. Specifications call for a minimum of 98 per cent $BaSO_4$, not more than 0.15 per cent Fe_2O_3, and a particle size range of 40 to 140 mesh. Consumption of barite in the glass industry, including glass fibre and glass wool, amounts to the largest percentage of total consumption, next to well drilling uses.

Where used as a filler in rubber goods the specifications for natural barite vary but the main factors are whiteness and particle size range. Some requirements,

Table 2. Canada, barite production, trade and consumption, 1963-72

	Production[1]	Imports	Exports	Consumption^r
	(short tons)			
1963	173,503	3,830	159,892	17,500
1964	169,149	3,206	156,527	15,800
1965	203,025	3,686	185,032	21,700
1966	221,376	4,165	199,054	26,500
1967	172,270	5,924	146,103	32,000
1968	138,059	7,901	116,491	29,500
1969	143,320	6,243	108,610	41,000
1970	147,251	7,526	99,544	55,200
1971	120,765	11,332	73,879	58,200
1972^p	73,000	21,858	20,188	74,700

Source: Statistics Canada.
[1] Mine shipments.
^r Revised estimates of total consumption by Statistics Section, Mineral Resources Branch; ^p Preliminary.

perhaps where weight is most desired, may allow for the use of off-white material.

The balance of Canada's barite consumption went for such diverse uses as the manufacture of ceramic products, soaps and detergents.

There is as yet no barium chemicals industry in Canada. Barium chemicals include: barium carbonate, which is the most important; chemical or precipitated barium sulphate, referred to in the trade as 'blanc fixe'; and lithopone, a chemically precipitated mixture of 70 per cent barium sulphate and 30 per cent zinc sulphide. Lithopone is a white pigment that has been largely replaced by titanium dioxide pigments. Specifications of barite for the barium chemicals industry are about 95 per cent $BaSO_4$, and not more than 1 to 2 per cent Fe_2O_3.

World review

There is worldwide production and considerable international trade in barite even though transportation costs in some cases may be nearly as great as the cost of the lump material. World production of barite in 1972 was estimated at 4.20 million tons of which about three quarters was consumed in oil well drilling. Dependence on this industry as a principal market means that demand is subject to considerable fluctuation as the tempo of oil and gas exploration varies in time and in geographic location. On the other hand, oil and gas exploration takes place throughout the world and on balance there is a consistent world demand that is most economically served by production from many countries. Viability of any deposit is dominantly influenced by transportation costs to markets.

Table 3. World production of barite, 1971-72

	1971	1972^e
	(short tons)	
United States	825,000	900,000
West Germany	451,000	450,000
Mexico	308,000	310,000
Italy	222,000	220,000
Ireland	177,000	180,000
Peru	143,000	150,000
France	116,000	120,000
Greece	109,000	110,000
Morocco	93,000	100,000
Yugoslavia	88,000	90,000
Canada	121,000	73,000
Other countries	1,484,000	1,500,000
Total	4,137,000	4,203,000

Source: U.S. Bureau of Mines Commodity Data Summaries, January 1973. Canadian totals from Statistics Canada.
^{e} Estimated.

In the United States, production of an estimated 900,000 tons annually is derived mostly from Missouri, Arkansas and Nevada, with smaller amounts from nine other states. This country generally imports about half a million tons of crude barite annually. The pattern of consumption of ground barite (excluding the barium chemicals industry) in the United States is similar to that in Canada.

Thailand reported a significant increase in barite shipments the past two years. A new milling plant on Batam Island, 10 miles south of Singapore, of P.T. Dresser Magcobar Indonesia and one situated in Singapore of Asian Mineral Products (Pty) Ltd., a subsidiary of Endeavor Oil Company N.L., process most of this output. The production capacity of the Dresser plant is about 45,000 tons of barite drilling mud a year and the capacity of the Endeavor plant is about 30,000 tons a year.

Outlook

Barite production by new Canadian producers is not expected in 1973, although there are many areas of known occurrences. Exploration for new deposits and feasibility studies presently under way on known deposits could bring about changes in the production pattern and the quantity of output in the near future. The increasing oil and gas well drilling activity off the east coast of Canada and the U.S. would indicate a growing market for barite in these areas.

CELESTITE

Celestite ($SrSO_4$), the main source of strontium, is used to produce commercial strontium compounds, principally strontium carbonate and strontium nitrate. Strontium carbonate is used in glass faceplates in colour television sets, where it improves the absorption of X-rays emitted by picture tubes operated at high voltages. An increasing use for this compound is in the manufacture of ferrites, a material required in the production of ceramic permanent magnets, which are being increasingly used in small motors.

Kaiser Celestite Mining Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Limited and the only producer of celestite in Canada, mined celestite ($SrSO_4$) ore from an open pit near Loch Lomand, Cape Breton Island, N.S. Concentrate was produced from a flotation mill at the mine site. The concentrate was shipped to the Point Edward, Nova Scotia plant of Kaiser Strontium Products Limited, for treatment with imported natural sodium carbonate to produce technical and chemical-grade strontium carbonate, commercial-grade strontium nitrate and sodium sulphate. Capacities of the plants are: 225 tons of $SrSO_4$ concentrate a day from the mill, 90 tons a day of $SrCO_3$, and up to 100 tons a day of sodium sulphate. There is capacity at the Point Edward plant to produce small quantities of strontium nitrate, used in pyrotechnics and tracer ammunition. The production of glass- and ceramic-grade strontium carbonate is expected in 1973. Research into new and expanded uses of strontium carbonate continues and a slow but steady growth in consumption is anticipated.

Current producers of strontium carbonate in the United States obtain most of their celestite from Mexico.

Prices

United States prices of barite according to Engineering and Mining Journal of December 1972

	($ per short ton)
Chemical and glass grade	
Hand picked, 95% $BaSO_4$ not over 1% Fe	22.50 - 24.50
Magnetic or flotation, 96% $BaSO_4$ not over 0.5% Fe	26.50 - 28.50
Imported drilling mud grade, specific gravity 4.20-4.30 cif	
Gulf ports	14 - 18
Canada	15
Ground	
Water, 99½% $BaSO_4$ 325 mesh, 50-lb bags	55 - 78
Dry ground drilling mud grade, 83-93% $BaSO_4$ 3-12% Fe, specific gravity 4.20-4.30	37-44
Imported, 4.20-4.30 specific gravity	31

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
49205-1	Drilling mud and additives	free	free	free
68300-1	Barites			
	On and after Jan. 1, 1971	free	12	25
	On and after Jan. 1, 1972	free	10	25
92842-1	Barium carbonate	10	15	25
92818-1	Barium oxide, hydroxide peroxide	10	15	25
93207-5	Lithopone	free	12½	25

United States

Item No.				
472.02	Barium carbonate, natural, crude	free		
		On and After January 1		
		1970	1971	1972
472.04	Barium carbonate, natural, ground	8.5%	7%	6%
		($ per lt)	($ per lt)	($ per lt)
472.10	Barium sulphate, natural	1.78	1.53	1.27
472.12	Barium sulphate, natural, ground	4.55	3.90	3.25
		(¢ per lb)	(¢ per lb)	(¢ per lb)
472.14	Barium sulphate, precipitated (blanc fixe)	0.43	0.35	0.3
473.72	Lithopone, containing under 30% zinc sulphide	0.6	0.52	0.43
473.74	Lithopone, containing 30% or more zinc sulphide	0.6 + 5%	0.5 + 4.5%	0.43 + 3.5%

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Bentonite

G. O. VAGT

Bentonite is a clay composed mainly of the mineral montmorillonite, a hydrated aluminum silicate with weakly attached cations of sodium and calcium. Bentonite has different properties depending on the proportion of sodium or calcium. The sodium bentonites have a great physical avidity for water which provides bentonite with unique swelling properties forming gels from 15 to 20 times the original dry volume. On agitation these gels may become fluid in character and then revert to a stable gel state when quiescent. Sodium bentonite also possesses a high dry-bonding strength, especially at elevated temperatures, and this ceramic feature is important in some uses.

Montmorillonite clays have high ion-exchange properties and by adsorption, absorption and chemical activity, bentonite can collect many types of inorganic and organic compounds, sometimes selectively. In general the nonswelling or calcium bentonites exhibit the more pronounced adsorptive characteristics. While naturally occurring clays may exhibit adsorptive or bleaching properties, their efficiencies are commonly improved by acid leaching or, as the process is generally termed, activation.

Another clay, 'fuller's earth', is also largely a montmorillonite clay and is very similar to nonswelling bentonite. These clays have natural bleaching and absorbent properties and were originally used by fullers to remove dirt and oil from wool. The terminology is confusing and bentonite and fuller's earth may or may not be separated in world trade and production figures by country.

Bentonite is generally accepted as originating from deposits of volcanic ash that have been altered by induration and weathering. The deposits occur in relatively flat-lying beds of various chemical compositions and impurities, the latter consisting of quartz, chlorite, biotite, feldspar and jarosite. Natural clay may be creamy white, grey, blue, green or brown and in places beds of distinctly different colour are adjacent. Fresh moist surfaces are waxy in appearance; on drying, the colour lightens and the clay has a distinctive cracked or crumbly texture.

Production and occurrences in Canada

Canadian bentonite occurrences are confined to Cretaceous and Tertiary rocks at many localities in Manitoba, Saskatchewan, Alberta and British Columbia. Although clay beds occur in rocks older than Cretaceous, none in Canada has been identified as bentonite. In the Truax area of Saskatchewan, south of Avonlea, Indusmin Limited continued an evaluation program on their bentonite prospect where previous diamond drilling indicated 4,000,000 tons of material. The recent program consisted of additional drilling, a comprehensive market survey, definition of processing methods and the determination of product characteristics. Preliminary tests indicate that the bentonite would be suitable for use in the pelletizing of iron ore and in iron foundries.

Three companies mine and process bentonite in Canada; statistics on total production are not available for publication.

In Alberta, Dresser Minerals Division of Dresser Industries, Inc. recovers swelling bentonite from the Edmonton Formation, of Upper Cretaceous age. The deposits are in the Battle River Valley, 9 miles south of Rosalind, the site of the company's processing plant. Baroid of Canada, Ltd. mines a similar bentonite from the same formation, about 14 miles northwest of the company's processing plant and rail siding at Onoway.

Bentonite is mined selectively from relatively shallow paddocks or pits in the dry summer months. Some natural drying may be done by spreading and harrowing material before trucking it to plants for further processing. Both companies dry, pulverize and bag the bentonite. Swelling bentonite from Alberta is used mainly as an oil well drilling mud additive but some is used as a binder in foundry sands and in feed pelletizing, as a fire-retardant additive to water and as a sealer for farm reservoirs.

In Manitoba, Pembina Mountain Clays Ltd. mines nonswelling bentonite from the Upper Cretaceous Vermilion River Formation, 19 miles northwest of Morden, which is in turn 80 miles southwest of Winnipeg. Some bentonite is dried and pulverized in a plant at Morden but the bulk of production is railed from Morden to the activation plant at Winnipeg, where it is leached, washed, filtered, dried, pulverized and bagged. The main use is for decolourizing and purifying mineral and vegetable oils, animal fats and tallows.

Uses, consumption and trade

Bentonite has many uses but generally constitutes only a small part of the final product.

Select swelling bentonite has found widespread and

Table 1. Canada, bentonite imports and consumption, 1971-72

	1971		1972ᵖ	
	(short tons)	($)	(short tons)	($)
Imports				
Bentonite				
United States	287,492	2,702,000	237,157	2,660,000
Greece	59,308	593,000	69,070	686,000
Total	346,800	3,295,000	306,227	3,346,000
Activated clays and earths				
United States	12,518	1,685,000	22,979	2,068,000
Greece	–	–	13,400	230,000
France	171	69,000	238	80,000
West Germany	10	3,000	10	2,000
Britain	–	–	5	1,000
Total	12,699	1,757,000	36,632	2,381,000
Fuller's earth				
United States	10,643	305,000	7,024	185,000
Britain	4	. . .	–	–
Total	10,647	305,000	7,024	185,000

Consumption[1] (available data)	1969	1970	1971
		(short tons)	
Pelletizing iron ore	211,209	243,744	223,787
Well drilling	18,327	24,833	17,624
Foundries	43,024	34,363	40,492
Chemicals	2,316	2,038	520
Fertilizer stock and poultry feed	225	69	95
Paint and varnish	175	219	368
Pulp and paper	198	191	194
Other products[2]	2,986	1,764	8,163
Total	278,460	307,221	291,243

Source: Statistics Canada.
[1]Includes fuller's earth. Breakdown by Mineral Resources Branch. [2]Explosives, frits and enamels, refractory brick and cements, ceramic products, gypsum and concrete products, petroleum refining and refining vegetable oils and other miscellaneous minor uses.
ᵖPreliminary: – Nil; . . . Less than one thousand dollars.

rapidly growing uses as a binder in the pelletizing of iron mineral concentrates. About 18 pounds is used in every long ton of concentrate to provide the pellet with sufficient 'green' strength to withstand handling during the drying and firing stages. The amount of bentonite required varies with the mineralogy and particle size of the concentrate.

Special muds used in oil and gas well drilling contain about 10 per cent swelling bentonite, which is used principally to prevent the loss of drilling fluid into permeable zones by coating the wall of the drill hole with a gel. It also serves as a lubricant and helps to keep the drill cuttings in suspension.

Swelling bentonite serves as a binder in moulding sands used by iron and steel foundries. Nonswelling bentonite is also used as a binder in some low-temperature foundries.

Swelling bentonite is used as a binder in the pelletizing of base-metal concentrates and stock feeds. It is used in small quantities as a plasticizer in abrasive and ceramic mixes; as a filler in paints, paper, rubber, pesticides, cosmetics, medicinal products, and cleaning and polishing compounds; in the grouting of subsurface water-bearing zones; and in the sealing of dams

Table 2. Canada, bentonite imports and consumption, 1963-72

	Imports[1]		Consumption[2]
	(short tons)	($)	(short tons)
1963	..	2,005,337	93,512
1964	123,533	1,659,076	161,695
1965	192,170	2,310,566	176,536
1966	204,038	2,606,000	201,022
1967	235,451	3,346,000	215,928
1968	323,093	4,041,000	231,349
1969	311,327	4,638,000	278,460
1970	386,984	5,590,000	307,221
1971	370,146	5,357,000	305,400
1972[p]	349,883	5,912,000	..

Source: Statistics Canada.
[1]Includes fuller's earth and activated clays and earths.
[2]Includes fuller's earth.
[p]Preliminary; .. Not available.

and reservoirs. Bentonite slurry is effective in fighting forest fires and in retaining the walls of excavations prior to the placement of concrete or other structural materials.

Some nonswelling bentonite is used in pelletizing stock feed, as a carrier for pesticides, and as a cleaning powder for animals.

Activated bentonite is used in decolourizing mineral and vegetable oils, animal fats, waxes, beverages and syrups. It is also used as a catalyst in the refining of fluid hydrocarbons.

Consumption of bentonite in Canada has increased greatly in the last decade (see Table 2), largely because of increased consumption as a binder in iron concentrate pelletizing as more of these plants have been constructed. Consumption of bentonite in well drilling in the oil and gas industry is subject to considerable fluctuation. Iron and steel foundries require bentonite as a binder for moulding sands; approximately 40,000 tons are used annually in Canada. Imports of bentonite from the United States continued to decrease in 1972 and Greek imports continued to increase. Relatively minor quantities of activated clays and fuller's earth are imported mainly from the United States and some activated bentonite from Manitoba is exported to the United States.

Bentonite production in the United States is centred on extensive deposits in Wyoming where the name was derived from the Cretaceous Fort Benton Formation. These Cretaceous deposits are the world's outstanding swelling bentonite occurrences and the specifications and standards for bentonite used in industry are based on these high-quality clays. Although there are numerous occurrences of bentonite in many countries it is mined in only a few. Because of the high standards of Wyoming bentonite this material is transported over such distances that transportation costs commonly exceed the value of the product at the mine, in some cases by several times. Canada is the main importer from the United States but some bentonite moves to Australia and western Europe. Nonswelling bentonite, fuller's earth and bleaching clays are produced in numerous states, the major ones being Florida, Georgia, Mississippi and Texas.

Outlook

The bulk of Canada's bentonite consumption is used in pelletizing iron ore concentrates. At present, the most suitable material for this purpose is imported from the United States. The development of a Canadian source of suitable material for pelletizing will depend on the results of the tests being carried out on the Saskatchewan bentonite and whether mining costs and freight rates are competitive. The slowdown in import growth since 1970 is attributed to more stabilized consumption patterns resulting from the completion of new pellet plants. However, a 6-million-ton-a-year iron ore pellet plant at Sept-Iles, Quebec, to be in operation in 1973, is expected to increase total imports by at least 50,000 tons a year. No other pellet plant construction is foreseen in the near or medium term. No major changes in production and consumption in industries other than in ore pelletizing are foreseen.

Prices

United States bentonite prices quoted in Oil, Paint and Drug Reporter, December 25, 1972

	($)
Bentonite, domestic, 200 mesh, bags, car lots, fob mines, per ton	14 - 14.40
Bentonite, imported Italian white, high gel, bags, 5-ton lot ex-warehouse, per ton	116.60

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
29500-1	Clays, not further manufactured than ground	free	free	free
93803-2	Activated clay	10%	15%	25%
20600-1	Fuller's earth, in bulk	free	free	free

Tariffs (concl'd)

United States

Item No.		On and After Jan. 1, 1972
		(¢ per long ton)
521.61	Bentonite	40
521.51	Fuller's earth not beneficiated	25
521.54	Wholly or partly beneficiated	50
521.87	Clays, artificially activated with acid or other material	0.05¢ per lb +6% ad val

Source: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), T.C. Publication 452.

Bismuth

M. GAUVIN

Bismuth is obtained in Canada as a byproduct in the processing of certain lead-zinc, lead-zinc-copper, molybdenum, and copper ores. The more important sources during 1972 were molybdenum ores mined in the Malartic district of northwestern Quebec, lead-zinc ores produced in southeastern British Columbia, and copper ore mined near Gaspé in eastern Quebec. Minor amounts were recovered from lead-zinc-copper ores mined in northeastern New Brunswick and from silver-cobalt ores produced in the Cobalt-Gowganda area of northern Ontario.

Based on preliminary figures, bismuth production in Canada in 1972 totalled 256,000 pounds valued at $919,000, compared with 271,196 pounds valued at $1,398,035 in 1971. The drop in production is mainly accounted for by the closure of the molybdenum-bismuth producing mines in northwestern Quebec. The last operating mine, the former Molybdenite Corporation of Canada Limited, closed in September 1972. Nigadoo River Mines Limited, whose lead concentrates contained appreciable amounts of bismuth, suspended operations in January 1972.

In 1972 world production of bismuth, excluding United States production, as estimated by the United States Bureau of Mines, was some 8.0 million pounds or up 1.5 per cent from 1971. Peru was the leading producer with an output of 1.7 million pounds followed by Bolivia, Mexico and Japan. The United States, which is a substantial producer from its own and imported ores, does not publish its production statistics.

World demand for bismuth rose significantly in 1972. After declining about 25 per cent in 1971, United States consumption rose substantially in 1972 and slightly exceeded that of 1970. The stronger demand was reflected by the stabilizing and firming of bismuth prices during the year.

Bolivia, traditionally a major supplier of bismuth ore, completed construction of its first bismuth smelter at Telemayu. It was officially inaugurated in May 1972. The plant is owned by Corporacion Minera de Bolivia (Comibol) and will result in Bolivia becoming a major producer of bismuth metal. The plant's initial monthly capacity is 400 metric tons of concentrates (grading 13-15 per cent bismuth and 8-10 per cent copper). The country's major bismuth deposits are located at the Tasna mines, Baracoles in the North Group and Esmoraca.

Peko-Wallsend Ltd. of Australia will soon become the world's largest producer of bismuth when its new copper smelting and bismuth recovery plant is completed in 1973. It is being constructed near Tennant Creek about 600 miles south of Darwin in the Northern Territory and will treat copper concentrates, currently exported to Japan, containing an appreciable amount of bismuth. When completed, the complex plant is expected to recover annually some 1,300 tons of bismuth as crude bullion.

Authorized sales of bismuth from the United States government stockpile totalled 235,457 pounds in 1972, and thus reduced the stockpile to its objective of 2,100,000 pounds. In March 1973 President Nixon submitted a bill to Congress proposing major reductions of materials contained in the governmental stockpiles. The bill includes a provision that the stockpile objective for bismuth be reduced to 95,900 pounds.

Outlook

World demand for bismuth will continue to follow the general trend of economic activity of the world's industrialized nations. Bismuth is mainly derived as a byproduct in the processing of lead and copper ores and with the expansion in world production of these ores, the new smelter in Bolivia beginning operations in 1972 and the Australian smelter scheduled to go on stream in 1973, world supply of bismuth should be able to meet any increase in demand.

Domestic sources

British Columbia. Cominco Ltd. remained the only producer of bismuth metal in British Columbia, deriving most of its output from lead concentrates produced at its Sullivan lead-zinc mine at Kimberley. Other sources included lead concentrates from other company mines and custom shippers. Lead bullion produced from the smelting of these concentrates contains about 0.05 per cent bismuth. Bismuth is recovered as 99.99+ per cent pure metal from the treatment of residues resulting from the electrolytic refining of the lead bullion. For use in research and in the electronics industry this bismuth is further processed to give it a purity of up to 99.9999 per cent.

Table 1. Canada, bismuth production and consumption, 1971-72

	1971		1972p	
	(pounds)	($)	(pounds)	($)
Production, all forms[1]				
British Columbia	82,521	448,089	94,000	337,000
Quebec	122,507	590,654	110,000	395,000
New Brunswick	37,680	204,602	35,000	126,000
Ontario	20,910	113,541	17,000	61,000
Northwest Territories	7,578	41,149	–	–
Total	271,196	1,398,035	256,000	919,000
Consumption, refined metal (available data)				
Fusible alloys and solders	4,126		4,879	
Other uses[2]	31,750		29,696	
Total	35,876		34,575	

Source: Statistics Canada.
[1]Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2]Includes bismuth metal used in manufacture of pharmaceuticals and fine chemicals, other alloys and malleable iron.
pPreliminary; – Nil.

Quebec. For many years the molybdenite mines of northwestern Quebec, which produced bismuth as a byproduct, were Canada's largest producers of bismuth. They produced metallic bismuth of about 95 per cent purity. However, because of economic conditions and the poor market for their product, output has been gradually declining and in September 1972, the last operating mine in the area, that of Molybdenite Corporation of Canada Limited, ceased production. Gaspé Copper Mines, Limited recovered bismuth in metal ingots from the treatment of flue dust derived from its copper-smelting operation at Murdochville, on the Gaspé Peninsula. Production statistics of the company are not available.

New Brunswick. The Smelting Division of Brunswick Mining and Smelting Corporation Limited produced bismuth metal at its plant at Belledune, about 25 miles northwest of Bathurst, New Brunswick. Production in 1972 amounted to 33,870 pounds of refined bismuth grading 99.9 per cent or better, compared with a production of 26,605 pounds in 1971. The Kroll-Betterton process is used to treat the desilverized lead bullion and produce a bismuth-lead-calcium-magnesium dross. The dross is then pyrometallurgically refined with chlorine to produce bismuth metal.

Uses

A major use of bismuth is in pharmaceuticals, cosmetics and industrial and laboratory chemicals including catalytic compounds. Various bismuth compounds, salts and mixtures are used in pharmaceuticals for indigestion remedies, antacids, burn and wound dressings. Insoluble salts of bismuth are given to patients before X-ray examination of the digestive tract. Cosmetics containing bismuth oxychloride which im-

Table 2. Canada, bismuth production, exports and consumption, 1963-72

	Production, All Forms[1]	Exports[2]	Consumption[3]
		(pounds)	
1963	359,125	399,772	47,800
1964	399,958	300,073	53,700
1965	428,759	..	48,300
1966	525,659	..	56,400
1967	668,476	..	47,900
1968	648,232	..	59,300
1969	579,059	..	33,800
1970	590,340	..	24,548
1971	271,196	..	35,876
1972p	256,000	..	34,575

Source: Statistics Canada.
[1]Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2]Refined and semirefined bismuth metal. [3]Refined bismuth metal reported by consumers.
pPreliminary; .. Not available.

Table 3. Estimated world production of bismuth, 1970-72

	1970	1971	1972^e
		(pounds)	
Japan (metal)	1,495,000	1,445,000	800,000
Peru	1,777,000	1,435,000	1,700,000
Bolivia	1,340,000	1,440,000	1,500,000
Mexico	1,259,000	1,260,000	1,400,000
People's Republic of China (in ore)	550,000^e	550,000^e	. .
Canada	590,000	271,000	256,000
Australia (in concentrates)	433,000	500,000	. .
South Korea	234,000	214,000	250,000
Yugoslavia (metal)	166,000	202,000	250,000
Romania (in ore)	180,000	180,000	. .
Other countries	384,000	394,000	1,850,000
Total[1]	8,408,000	7,891,000	8,006,000

Sources: Statistics Canada for Canada; for remaining countries, U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1971 and U.S. Commodity Data Summaries, January 1973.
[1]Total for listed figures only; excludes U.S. production which is not available for publication, and that of some other smaller producing countries.
^{e}Estimate; . . Not available.

Table 4. United States consumption of bismuth by principal uses, 1971-72

	1971	1972^p
	(pounds)	
Fusible alloys	514,203	735,902
Other alloys	17,439	18,902
Pharmaceuticals[1]	724,592	1,003,880
Experimental uses	26,175	–
Metallurgical additives	362,527	468,702
Other uses	3,782	4,000^e
Total	1,648,718	2,231,386

Source: Mineral Industry Surveys, United States Department of the Interior, Bureau of Mines, Bismuth in the Fourth Quarter 1972.
[1]Includes industrial and laboratory chemicals.
^{p}Preliminary; ^{e}Estimate; – Nil.

parts a 'pearlescent' glow to eye shadow, lipstick, nail polish and powders comprise one of the larger end-use markets of bismuth, but consumption in this market depends on changing fashion trends and is declining.

Another important outlet for the metal is in fusible or low-melting-point alloys for fire-protection devices, electrical fuses, fusible plugs and solders. Many of these alloys contain 50 per cent or more bismuth with the chief additive metals being cadmium, lead and tin. In safety applications, the dependability of the melting temperatures of the various bismuth alloy compositions is of utmost importance. Pure bismuth metal expands 3.3 per cent on changing from a molten to a solid state. Nonshrinking low-melting-point bismuth alloys are used in the holding of air foil blades for jet engines during the machining of the root section. Type metal contains bismuth because of the expanding property of bismuth alloys.

The metal is also used as an important additive to improve the machinability of aluminum alloys, malleable irons and steel alloys and with indium forms a low-melting alloy used for holding lenses in the opthalmic industry. Until 1969, bismuth-molybdate catalysts had been used in the production of acrylic plastics but other catalysts have since displaced it. The United States Atomic Energy Commission uses bismuth in many nuclear research applications because of the metal's low thermal neutron absorption rate.

Prices

The Canadian price for bismuth, as quoted by Cominco Ltd., for bars 99.99 per cent pure, was $3.50 a pound in lots of 1 ton or more from January 1 to October 4, 1972. From October 5 to the end of the year Cominco's price was $4 a pound. The United States price in ton lots, as published by *Metals Week* was U.S. $3.50 a pound from January 1 to September 30. On October 1 it was raised to $4 a pound where it remained for the balance of the year.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
33100-1	Bismuth ores and concentrates	free	free	free
35106-1	Bismuth metal, not including alloys, in lumps, powders, ingots or blocks	free	free	25%

United States

Item No.		
601.66	Bismuth ores and concentrates	free
632.10	Bismuth metal, unwrought; waste and scrap	free
632.64	Bismuth alloys containing by weight not less than 30% lead	free

Item No.		On and After January 1		
		1970	1971	1972
		(% ad val.)		
632.66	Other	12.5	10.5	9
633.00	Bismuth metal, wrought			

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Cadmium

G.S. BARRY AND M. GAUVIN

Cadmium in nature occurs predominantly as a sulphide greenockite, which is found associated with zinc sulphide ores, especially sphalerite the common zinc ore mineral. This association with zinc minerals continues during the milling process and it is recovered as a byproduct of zinc refining. Canadian zinc ores contain up to 0.07 per cent cadmium and zinc concentrates contain up to 0.7 per cent cadmium. Cadmium is recovered from zinc concentrates that grade 0.1 to 0.3 per cent cadmium.

Canadian production in 1972, as reported by Statistics Canada, was 3,924,000 pounds, a small decrease from 1970. This amount represents the metallic cadmium recovered at domestic smelters from Canadian ores, plus the recoverable cadmium content of ores and concentrates exported.

Cadmium is recovered at electrolytic plants as a precipitate or oxide sponge produced during the purification of the zinc electrolyte. In Canadian plants, the metal is then produced either by the electrolytic process, where cadmium is redissolved in sulphuric acid and plated out in electrolytic cells, or by a purification process in which the sponge is briquetted, melted in an electric furnace, de-zinced and cast. At zinc primary distillation plants, cadmium is reduced and vapourized with zinc in a retort or furnace. The vapour is condensed and cadmium (B.P. 776°C) is separated from zinc (B.P. 905°C) by fractional redistillation.

Metallic cadmium is recovered as a byproduct at the electrolytic zinc plants of Cominco Ltd. at Trail, British Columbia; Hudson Bay Mining and Smelting Co., Limited at Flin Flon, Manitoba; and Canadian Electrolytic Zinc Limited at Valleyfield, Quebec. The Smelting Division, Brunswick Mining and Smelting Corporation Limited, recovered small amounts of cadmium at its Belledune, New Brunswick Imperial Smelting Process lead-zinc smelter until January 1972 when it began converting the smelter to one treating only lead concentrates. Small initial quantities were also recovered at Ecstall's new plant near Timmins. In 1972 metallic cadmium produced in Canada totalled 2,251,094 pounds compared with 1,568,787 pounds in 1971.

The United States continued to be the world's largest producer of metal with a smelter output in 1971 of 4,350 tons from primary and secondary sources. Japan, the U.S.S.R. and Canada are the next largest cadmium metal producers.

Canadian exports of refined cadmium totalled 2,261,621 pounds compared with 1,438,789 pounds in 1971. The United States, Britain and The Netherlands remained Canada's largest customers importing over 95 per cent of Canada's exports.

The available data indicates that Canadian consumption continues to drop. It is estimated at 114,403 pounds in 1972 down from 117,395 pounds in 1971. Apparent consumption in the United States rose from 10.8 million pounds in 1971 to 13.2 million pounds in 1972. Cadmium consumption can only be estimated crudely as "apparent" since there is no way to check consumers' inventory changes and these are known to fluctuate widely.

World demand improved substantially during 1972 and was reflected in a large drop in producer stocks and a rise in Canadian and United States producer prices during the year. Producer prices which were $1.50 at the end of 1971 rose in the first quarter of the year to $2.60 and remained at that level until November when they rose to $3.00 and were firm at the end of the year. Japanese producers were cited in 1971 for making sales in the United States at "less than fair value". Hearings were held by the Tariff Commission in 1972 and on June 23 the Commission notified the Secretary of the Treasury that an industry was being injured by reason of the importation of cadmium from Japan sold at less than fair value on the domestic market. The Treasury will police Japanese imports for at least 24 months before the dumping penalty procedure is removed. No imports of cadmium were made into the United States from Japan during the last three quarters of 1972. The United States stockpile disposed of 934,546 pounds during the year and at the end of 1972 had a total inventory of 9,213,358 pounds of which 3,213,358 pounds were authorized for release.

The strong demand that existed in 1972 carried through into 1973 and is expected to continue throughout the year in the major uses of the metal.

Canadian production

Table 4 lists data on cadmium production as reported by individual mines. Additional information is given in the following review by provinces:

Newfoundland. The Buchans Unit of American Smelting and Refining Company remains the only producer

Table 1. Cadmium production, exports and consumption, 1971-72

	1971[r]		1972[p]	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Ontario	2,414,008	4,683,176	2,414,000	6,108,000
British Columbia	1,036,713	2,011,233	672,000	1,700,000
Quebec	126,730	245,856	287,000	726,000
Manitoba	102,901	199,628	281,000	710,000
Saskatchewan	33,873	65,714	79,000	200,000
Yukon	59,100	114,654	13,000	33,000
New Brunswick	135,080	262,055	33,000	83,000
Northwest Territories	155,400	301,476	145,000	367,000
Total	4,063,805	7,883,782	3,924,000	9,927,000
Refined[2]	1,568,787		2,251,094	
Exports				
Cadmium metal				
United States	380,225	664,000	1,290,117	2,831,000
Britain	436,640	836,000	615,959	1,313,000
Netherlands	492,791	626,000	253,992	466,000
India	35,986	54,000	55,152	98,000
Belgium and Luxembourg	70,628	83,000	22,046	27,000
Brazil	–	–	11,013	26,000
Other countries	22,519	37,000	13,342	11,000
Total	1,438,789	2,300,000	2,261,621	4,772,000
Consumption (cadmium metal)[3]				
Plating	86,873		78,931	
Solders	4,301		5,705	
Other products[4]	26,221		29,767	
Total	117,395		114,403	

Source: Statistics Canada.
[1]Production of refined cadmium from domestic ores, plus recoverable cadmium content of ores and concentrates exported. [2]Refined metal from all sources and cadmium sponge. [3]Available data reported by consumers. [4]Mainly chemicals, pigments, and alloys, other than solder.
[p]Preliminary; – Nil; [r]Revised.

in Newfoundland. Production was substantially higher in 1972 following a prolonged strike in 1971.

New Brunswick. Brunswick Mining and Smelting Corporation Limited, which operates two mines near Bathurst, no longer produces cadmium at its smelter at Belledune. All its zinc concentrates are now exported for treatment at foreign smelters. Nigadoo River Mines Limited suspended operations in January 1972.

Quebec. Canadian Electrolytic Zinc Limited (CEZ) at Valleyfield recovers refined cadmium from the zinc concentrates at the Mattagami and Orchan mines of northwestern Quebec and from the Geco mine, in Ontario. The zinc concentrates of northwestern Quebec are low in cadmium containing from 0.11 to 0.16 per cent. Production of the CEZ plant in 1972 was 854,000 pounds, up sharply from the 378,000 pounds reported in 1971 due to the processing of an intermediate product which accumulated in 1971.

Ontario. Ecstall Mining Limited at Timmins, the largest producer of cadmium in Canada produced a record amount of zinc concentrates grading approximately 0.24 per cent cadmium and containing slightly less cadmium than it produced in 1971. The new electrolytic zinc plant began operation in the second quarter of 1972 but the cadmium section with a capacity of 1,000,000 pounds of cadmium, did not produce until late in the year and produced 173,000 pounds of metal. Other zinc-copper mines in Ontario

Table 2. Canada, cadmium production, exports and consumption, 1963-72

	Production		Exports	
	All Forms[1]	Refined[2]	Cadmium Metal	Consumption[3]
	(lb)	(lb)	(lb)	(lb)
1963	2,475,485	2,354,000	1,939,110	209,000
1964	2,772,984	2,501,921	1,623,679	178,000
1965	1,755,925	1,790,488	1,364,645	172,000
1966	3,236,862	2,217,322	2,012,323	171,000
1967	4,836,317	2,002,892	1,676,676	155,000
1968	5,014,965	2,113,949	1,802,780	125,000
1969	5,213,054	2,123,955	1,686,573	132,136
1970	4,307,953	1,844,706	1,549,035	124,959
1971	4,063,805	1,568,787	1,438,789	117,395
1972[p]	3,924,000	2,251,094	2,261,621	114,403

Source: Statistics Canada.
[1] Production of refined cadmium from domestic ores, plus cadmium content of ores and concentrates exported. [2] Refined cadmium from all sources, including that obtained from imported lead and zinc concentrates; includes cadmium in sponge. [3] As reported by consumers.
[p] Preliminary.

Table 3. World smelter production of cadmium

	1971[r]	1972
	(short tons)	
U.S.A.	3,965	4,145
Japan	2,949	3,339
U.S.S.R.	2,646	2,646
Canada	784	1,125
Belgium	1,044	1,250
Federal Republic of Germany	1,083	1,090
France	638	640
Australia	615	620
Poland	441	386
Italy	386	452
Other countries	2,301	2,816
Total	16,852	18,509

Sources: World Bureau of Metal Statistics; for Canada, Statistics Canada.
Note: Data are for production of cadmium as unwrought metal from domestic and imported materials. Secondary metal is included where known, but the total in aggregate is less than one per cent of the world total. 1972 figures from United States Bureau of Mines, Commodity Data Summaries, January 1974.
[r] Revised.

produce zinc concentrates carrying low to moderate cadmium values. Noranda Mines Limited's Geco mine at Manitouwadge is the second largest producer next to Ecstall. Its concentrates, grading approximately 0.38 per cent cadmium, are treated by Canadian Electrolytic Zinc Limited.

Manitoba and Saskatchewan. The electrolytic zinc plant of Hudson Bay Mining and Smelting Co., Limited at Flin Flon treats zinc concentrates produced in these two provinces. Production at this plant was 386,768 pounds of cadmium in 1971.

British Columbia. Metallic cadmium amounting to 1,122,000 pounds was recovered at the metallurgical works of Cominco Ltd. at Trail. Cominco treats ores and concentrates from its own mines in British Columbia, from its subsidiary Pine Point Mines Limited, N.W.T., and on a custom basis, from various mining operations in British Columbia and other provinces. The Bradina Joint Venture near Houston began operations during the year while the Annex mine of Reeves MacDonald Mines Limited increased its production of zinc concentrates containing 0.62 per cent cadmium.

Yukon Territory. United Keno Hill Mines Limited mines silver-lead-zinc ore high in cadmium, recovering 45,490 pounds in 1972. Anvil Mining Corporation Limited is a large producer and exporter of zinc concentrates which are believed to be low in cadmium.

Northwest Territories. Pine Point Mines Limited continued to be the only supplier of cadmium in the Northwest Territories shipping zinc concentrates which are mainly smelted at Trail. The Pine Point ores have a low cadmium content.

Uses

Cadmium is a soft, ductile, silvery-white electropositive metal with a valence of two. It is used mainly for electroplating other metals or alloys, principally iron and, to a lesser extent, copper, to protect them against oxidation. A cadmium coating, like a zinc coating, protects those metals lower in the electromotive series by physical enclosure and by sacrificial corrosion. Cadmium is usually preferred to zinc as a coating because it is more ductile, is slightly more resistant to common atmospheric corrosion, can be applied more uniformly in recesses of intricately shaped parts, and can be electrodeposited with less electric current per unit of area covered. It is also preferred for its more pleasing aesthetic appearance. Because it is more costly and much less plentiful than zinc, it is not as widely used. Improvement in zinc electroplating techniques in recent years have tended to reduce the consumption of cadmium in plating.

Cadmium-plated articles are used in the manufacture of automobiles, household appliances, aircraft, radios, television sets and electrical equipment. Plating accounts for about half the total consumption of cadmium. *(Continued on page 64)*

Table 4. Companies reporting cadmium production, 1972 (and 1971)

Company and Location	Mill Capacity	Grade of Zinc Concentrates: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Contained in Zinc Concentrate	Remarks
	tons ore day	%	%	%	%	oz/ton	tons	pounds	
Newfoundland									
American Smelting and Refining Company (Buchans Unit) Buchans	1,250 (1,250)	0.22 (0.21)	56.66 (56.23)	3.83 (4.07)	0.73 (0.75)	4.39 (4.68)	52,990 (29,870)	231,000 (127,000)	Company reports 6 to 7 years ore reserves remaining.
New Brunswick									
Nigadoo River Mines Limited Robertville	– (1,000)	– (0.69)	– (46.00)	– (1.49)	– (1.12)	– (5.79)	– (14,379)	– (199,274)	Operations suspended Jan. 4, 1972.
Quebec									
Joutel Copper Mines Limited Joutel	– (–)	0.14 (–)	52.12 (–)	0.40 (–)	0.36 (–)	1.58 (–)	12,974 (–)	36,326 (–)	Ore custom treated at Mines de Poirier concentrator. Company began mining separate zinc orebody in August 1972.
Manitou-Barvue Mines Limited Val-d'Or	1,600 (1,600)	0.18 (. .)	54.00 (57.46)	. . (. .)	. . (. .)	. . (. .)	920 (6,210)	3,312 (. .)	Operations suspended October 1971 to July 1972. Plan to increase production in 1973.
Orchan Mines Limited Matagami	1,900 (1,900)	0.11 (. .)	53.8 (53.4)	. . (. .)	. . (. .)	. . (. .)	67,250 (74,373)	147,950 (. .)	Garon Lake mine being prepared for production.
Sullivan Mining Group Ltd., Stratford Centre Cupra, D'Estrie and Weedon mines	1,500 (1,500)	0.30 (0.28)	56.08 (56.43)	0.43 (0.51)	1.22 (1.74)	1.24 (1.29)	13,362 (11,669)	80,000 (65,345)	The Cupre Division operates a concentrator for all three mines. The Weedon mine is expected to close during 1973.

Table 4 (cont'd)

Company and Location	Mill Capacity	Grade of Zinc Concentrates: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Contained in Zinc Concentrate	Remarks
	tons ore/ day	%	%	%	%	oz/ton	tons	pounds	
Ontario									
Ecstall Mining Limited	10,000	. .	52.15	. .	0.38	5.46	622,365	3,034,000	The company's electrolytic zinc plant commenced operation in April 1972 but the cadmium section of the plant with a capacity of 1,000,000 pounds of cadmium produced only 173,000 pounds because of delays in delivery of equipment.
Timmins	(10,000)	(. .)	(52.77)	(0.47)	(0.36)	(4.26)	(595,413)	(3,214,000)	
Noranda Mines Limited,	5,200	0.38	52.95	–	0.76	1.64	115,626	868,066	Cadmium contained in zinc concentrates treated by Canadian Electrolytic Zinc Limited, Valleyfield, Que.
Geco Division, Manitouwadge	(5,000)	(. .)	(53.89)	(–)		(1.81)	(146,552)		
Selco Mining Corporation Limited	500	. .	. .	. .	. .	. .	42,100	210,500	Ramp from 300 to 600 level completed. Commenced mining below 300 level.
South Bay Division, Uchi Lake	(500)	(. .)	(52.02)	(. .)	(0.38)	(. .)	(26,969)	(. .)	
Willroy Mines Limited	1,700	0.18	53.08	. .	0.50	. .	20,878	77,466	Extensive exploration program planned for 1973.
(incl. Willecho mine) Manitouwadge	(1,600)	(. .)	(52.77)	(0.07)	(0.54)	(1.20)	(22,522)	(81,001)	
Manitoba and Saskatchewan									
Hudson Bay Mining and Smelting Co., Limited,	6,800	. .	48.06	. .	0.82	1.04	85,416	193,912	Flexar mine closed in 1972. White Lake and Ghost Lake mines started production.
Flin Flon	(7,500)	(. .)	(47.90)	(0.30)	(0.90)	(0.90)	(45,900)	(274,042)	
British Columbia									
Bradina Joint Venture	600	0.28	46.96	6.13	1.18	23.56	8,365	46,847	Mill commenced operation in March 1972.
Houston	(–)	(–)	(–)	(–)	(–)	(–)	(–)	(–)	

Table 4 (concl'd)

Company and Location	Mill Capacity	Grade of Zinc Concentrates: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Contained in Zinc Concentrate	Remarks
	tons ore/day	%	%	%	%	oz/ton	tons	pounds	
British Columbia (concl'd)									
Cominco Ltd., Sullivan mine, Kimberley	10,000 (10,000)	. . (. .)	48.60 (48.60)	4.50 (5.46)	– (–)	2.55 (. .)	195,374 (202,320)	. . (. .)	Cominco's total output of cadmium from all sources was 561 tons in 1972.
Kam-Kotia-Burkam Joint Venture Silmonac mine, Sandon	150 (150)	0.45 (0.42)	54.67 (54.20)	. . (. .)	– (–)	67.37 (79.00)	2,708 (3,998)	24,259 (33,721)	
Reeves MacDonald Mines Limited Annex mine, Remac	1,000 (1,000)	0.62 (0.33)	51.93 (50.77)	1.12 (1.99)	– (–)	6.15 (1.25)	22,498 (1,996)	278,527 (13,291)	Developing new ore zone under Pend d'Oreille River.
Reeves mine, Remac		– (0.62)	– (50.87)	– (0.79)	– (–)	– (4.96)	– (25,962)	– (323,740)	Operations suspended in 1971 because of ore depletion.
Teck Corporation Limited Beaverdell mine, Beaverdell	115 (115)	0.49 (0.42)	47.60 (45.17)	2.13 (1.99)	– (–)	65.28 (54.50)	380 (306)	3,713 (2,592)	Exploration and development work continues to locate new ore.
Western Mines Limited Buttle Lake, Vancouver Island	1,100 (1,000)	. . (0.25)	53.14 (53.20)	1.02 (1.38)	1.09 (1.09)	4.08 (3.70)	. . (38,003)	168,662 (193,550)	New additions made to concentrator in 1972 to mill high grade silver ore from the Myra Falls mine.
Yukon Territory									
United Keno Hill Mines Elsa	550 (550)	0.78 (0.70)	59.60 (54.30)	. . (0.90)	– (–)	19.10 (12.40)	2,916 (6,388)	45,490 (89,024)	Installed new hydraulic backfill plant for cut and fill stopes.

The second largest use is in the manufacture of pigments. Cadmium sulphides give yellow to orange colours and cadmium sulphoselenides give pink to red and maroon. Cadmium stearates act as stabilizers in the production of polyvinyl chloride plastics, and cadmium phosphors are used in both black-and-white and colour television tubes. The use of cadmium compounds in recent years has expanded at a rate of 5 to 10 per cent annually and is now the largest potential growth area. Expansion in this use has more than made up for reduced consumption in plating.

Cadmium is a valuable alloying metal and has applications in cadmium-silver solders and in cadmium-tin-lead-bismuth fusible or low-melting-point alloys for automatic sprinkler systems, fire-detection apparatus, and valve seats for high-pressure gas containers. Low-cadmium copper (about 1 per cent cadmium) is used in the manufacture of trolley and telephone wires because of the improved tensile strength imparted by cadmium. Low-cadmium copper is also now employed in automobile radiator finstock, replacing the low-silver copper formerly used.

Another growing application is in the production of nickel-cadmium storage batteries. These batteries are considerably more expensive than the standard lead-acid battery, but have a longer life and higher peak power output, are smaller, and are superior in low-temperature operation. They are especially suitable for use in airplanes, satellites, missiles and ground

Prices

Canadian producers' cadmium prices throughout 1972, as quoted in The Northern Miner. sticks, bars, balls, 99.98%

Effective Date	Lots of 5,000 lb and over	Lots under 5,000 lb
	($ per lb)	($ per lb)
January 6	1.75	1.95
February 3	2.25	2.45
March 16	2.60	2.80
November 2	3.00	3.20

United States producers' prices throughout 1972, as quoted by Engineering Mining Journal

Effective Date	One-Ton Lots	Lots of less than One Ton
	($ per lb)	($ per lb)
January 4	1.75	1.80
February 1	2.25	2.30
March 10	2.60	2.65
November 1	3.00	2.95

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
32900-1	Cadmium in ores and concentrates	free	free	free
35102-1	Cadmium metal, not including alloys in lumps, powders, ingots or blocks	free	free	25%

United States

Item No.				
601.66	Cadmium in ores and concentrates	free		
		On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
632.14	Cadmium metal, unwrought, waste and scrap (duty on waste and scrap suspended on or before June 30, 1973)	1¢ per lb	free	free
633.00 / 632.84	Cadmium metal, wrought / Cadmium alloys, unwrought	12.5%	10.5%	9%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publications 452.

equipment for polar regions, as well as in portable items such as battery-operated shavers, toothbrushes, drills and hand saws.

Outlook

Cadmium is a byproduct of zinc mining and refining and the ups and downs of cadmium supply, demand and prices are closely related to general economic activity and zinc production. The cadmium market is a relatively small market and small changes can make a big difference in prices. In line with the expectation that the economic recovery of 1972 will continue in 1973, cadmium demand and prices are expected to rise. Sales from the United States stockpile can be expected to have a stabilizing effect on price fluctuations and to moderate price increases. The world is becoming increasingly aware of the poisonous nature of some cadmium compounds but the problems that have plagued the industry are being controlled. The electroplating industry has introduced a closed loop waste disposal system, which, it is claimed, prevents the release of cadmium into waterways.

Calcium

D. G. SCHELL

Calcium is a lightweight, chemically reactive metallic element belonging to the alkaline earth group. It is the fifth most abundant element in the earth's crust but does not occur naturally in its elemental form. High-calcium limestone deposits are the principal source of calcium metal.

There are only three producers of metallic calcium in the noncommunist world: Chromasco Corporation Limited in Canada, Charles Pfizer and Co. Inc. in the United States and Planet-Wattohm S.A., a subsidiary of Compagnie de Mokta, in France. All three utilize a thermal reduction process. Statistics on world production and consumption of calcium are not available.

Canadian industry

Chromasco Corporation Limited produces calcium metal at its Haley smelter, near Renfrew, Ontario. It utilizes the same vacuum retort method, known as the 'Pidgeon process', used to produce its main product, magnesium. Other minor metals produced are barium, strontium and thorium. To make calcium, high-purity quicklime (CaO) and commercially pure aluminum are briquetted and then charged into horizontal retorts made of chrome-nickel steel. Under vacuum and at a temperature of about 1170°C, the aluminum reduces the quicklime to form a calcium vapour. This calcium vapour crystallizes at about 680°–740°C in the water-cooled condenser section of the retort, which projects outside the furnace wall. The initial product, known as 'crowns', contains about 98 per cent calcium. Higher purities are obtained by subsequent refining operations.

Chromasco makes four main grades of calcium: Grade 1 – chemical standard, 99.9 per cent calcium and minor amounts of other elements; Grade 2 – nuclear quality, 99.9 per cent calcium plus magnesium; Grade 4 – commercial grade (crowns), 98 per cent calcium, 0.5 to 1.5 per cent magnesium, 1 per cent nitrogen maximum, 0.35 per cent aluminum maximum; Grade 5 – lead-refining grade, 95 per cent calcium.

Canadian production of calcium metal increased to 477,000 pounds in 1972, 34 per cent more than the 355,247 pounds produced in the previous year, although well below the 942,682 pounds produced in 1969. Much of our production is exported, 253,100 pounds being sold in foreign markets in 1972, compared with 152,900 pounds in 1971.

Table 1. Canada, calcium production and exports, 1971-72

	1971		1972^p	
	(pounds)	($)	(pounds)	($)
Production (metal)[1]	355,247	291,504	477,000	342,000
Exports (metal)				
West Germany	6,600	9,000	125,600	90,000
Belgium and Luxembourg	22,000	9,000	44,000	26,000
Britain	9,400	17,000	9,400	18,000
United States	31,200	3,000	58,300	10,000
Japan	6,600	6,000	11,600	9,000
Israel	55,100	77,000	–	–
People's Republic of China	22,000	16,000	–	–
Other countries	–	–	4,200	2,000
Total	152,900	137,000	253,100	155,000

Source: Statistics Canada.
[1]Shipments of calcium metal, and calcium metal used in production of calcium alloys.
[p]Preliminary; – Nil.

Table 2. Canada, calcium production and exports, 1963-72

	Production[1]	Exports
	(pounds)	
1963	98,673	92,100
1964	138,357	130,800
1965	159,434	148,300
1966	249,179	242,800
1967	543,692	513,000
1968	468,511	353,700
1969	942,682	724,600
1970	443,557	174,100
1971	355,247	152,900
1972[p]	477,000	253,100

Source: Statistics Canada.
[1]Producers' shipments of calcium metal, and calcium metal used in production of calcium alloys.
[p]Preliminary.

Uses

Metallic calcium is a powerful reducing agent. It is used in metallurgical processes for removing oxygen and halogens from various metals which resist reduction by normal reductants such as carbon, hydrogen and natural gas. Among these metals are titanium, zirconium, vanadium, niobium and uranium. As a purifier, calcium removes residual sulphur, phosphorus and oxygen from steel and removes bismuth, antimony and arsenic from lead. Metallic calcium is also used in producing organocalcium compounds for special lubricants, corrosion inhibitors and detergents. In certain types of storage batteries, a lead alloy containing only 0.1 per cent calcium exhibits properties superior to an alloy of 3 per cent antimony normally used. Substitution in this field probably will be the most important factor in any future growth of calcium consumption.

Outlook

As limestone and other calcium minerals are readily available and inexpensive, a shortage of raw materials is almost impossible. Consumption of calcium metal is very limited and, unless its use is greatly accelerated, existing producers will be able to supply the market adequately in the foreseeable future. Prices are expected to remain stable.

Prices

Calcium prices remained unchanged in 1972 for the most used products. According to *Metals Week*, December 25, 1972, United States prices were as follows:

	(¢ per lb)
Calcium metal, ton lots, full crowns	95
Calcium alloys, fob shipping point, freight equalized to nearest main producer, carload lots	
calcium silicon, 32% calcium	24.75
calcium-manganese silicon	38.5

Tariffs

Canada

Item No.		Most Favoured Nation
		(% ad val.)
92805-1	Calcium metal	15

United States

Item No.		On and After January 1 1971	1972
		(% ad val.)	
632.16	Calcium metal, unwrought	9	7.5
633.00	Calcium metal, wrought	10.5	9

Source: Canada – The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. United States – Tariff Schedules of the United States (Annotated) 1972, T.C. Publication 452.

Cement

D. H. STONEHOUSE

Portland cement is produced by burning, usually in a rotary kiln, an accurately proportioned, finely ground mixture of limestone, silica, alumina and iron oxide. Kiln discharge, in the shape of rough spheres, is a fused, chemically complex mixture of calcium silicates and aluminates termed clinker, which is mixed with gypsum 4 to 5 per cent by weight, and ground to a fine powder to form portland cement. By close control of the raw mix, of the burning conditions and of the use of additives in the clinker grinding procedure, finished cements displaying various desirable properties can be produced.

There are three basic types of portland cement used in Canada – Normal Portland, High Early Strength Portland and Sulphate-Resisting Portland – all of which are covered in specifications under CSA Standard A5 – 1971 (Canadian Standards Association). Moderate and low-heat cements, designed for mass concrete use such as in dam construction, are manufactured by several companies in Canada. Masonry cements produced in Canada should conform to the requirements of CSA Standard A8 – 1970. The generic name masonry cement includes such proprietary names as Mortar Cement, Mortar Mix (unsanded), Mason's Cement, Brick Cement and Masonry Cement. The latter, produced by portland cement manufacturers, is a mixture of portland cement, finely ground, high-calcium limestone (35 to 65% by weight) and a plasticizer. The other products do not necessarily consist of portland cement and limestone and may include a mixture of portland cement and hydrated lime and/or other plasticizers.

The types of cement manufactured in Canada and not covered by the CSA standards generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

Cement has little use alone but when combined with water, sand, gravel, crushed stone or other aggregates in proper proportions, it acts as a binder cementing the materials together as concrete. Concrete has become a widely used and readily adaptable building material which can be poured on site in large engineering construction projects such as dams or can be used in the form of delicate precast panels or heavy prestressed columns and beams in building construction.

Summary, 1972

Cement is one of a number of industrial mineral commodities produced in Canada in direct support of the construction industry. Others include clays, lime, sand and gravel, stone, asbestos, and gypsum. The construction industry is the largest single employer in Canada and is one that is immediately affected by changes in the country's economic climate. In a supply role to a volatile industry the cement industry in turn must be capable of adjusting and remaining competitive. A growing export market for cement in northeastern United States, assisted by the diversion of United States cement to the south and southeast where construction activity has rapidly expanded, has resulted in the Canadian cement industry being influenced, at least regionally, by construction activity and intentions in that country.

In Canada in 1972 the value of construction was $16.3 billion, up from $15.7 billion in 1971. Housing starts reached a record 249,914 in 1972, up 7 per cent from the previous year, and showed a marked trend towards single-family dwellings as residential construction accounted for about 30 per cent of total construction spending and approximately the same proportion of cement consumption. During 1972 the selling price index for cement increased 6.6 per cent to 139.4; for concrete products the index rose 3.7 per cent to 132.1. Average construction labour hourly earnings rose nearly 12 per cent during the same period.

As the volume of construction tends to lessen per unit of expenditure, advances in construction techniques and equipment tend to improve the efficiency of an industry that is subject to many outside influences over which it has little or no control.

A typical feature of cement manufacturers is their diversification and vertical integration into related construction materials industries. Many cement companies also supply ready-mix concrete and stone aggregates as well as preformed concrete products such as slabs, bricks and prestressed concrete units.

Markets for cement tend to be regional because transportation costs represent much of the laid-down price to the consumer and only rarely, in the case of special cements, are shipments made beyond normal distribution boundaries. Production, therefore, is determined by the regional construction activity and by interpretation of construction intentions. In 1972, cement production in each of the three westernmost provinces was somewhat lower than in 1971 while that in all other provinces was increased in line with forecast construction spending.

Current production capacity appears to be 14.9 million tons a year (see Table 3) exclusive of three plants which only grind clinker and still including some capacity which could be reactivated only at considerable expense. With production at 10,010,000 tons, the industry's capacity utilization was 67 per cent for the year.

Production capacity was increased by about

Table 1. Canada, cement production and trade, 1971-72

	1971		1972p	
	(short tons)	($)	(short tons)	($)
Production[1]				
By province				
Ontario	3,570,397	68,300,184	3,743,000	71,611,000
Quebec	2,618,487	51,348,775	3,214,000	63,036,000
British Columbia	906,302	24,365,881	885,000	23,803,000
Alberta	875,401	19,696,405	938,000	21,096,000
Manitoba	487,356	13,143,214	550,000	14,838,000
Nova Scotia	..	4,837,562	..	4,759,000
Saskatchewan	146,019	3,791,393	169,000	4,401,000
New Brunswick	..	2,828,890	..	4,232,000
Newfoundland	..	2,932,090	..	2,564,000
Total	9,066,795	191,244,394	10,010,000	210,340,000
By type				
Portland	8,758,524		9,670,000	
Masonry[2]	308,271		340,000	
Total	9,066,795	191,244,394	10,010,000	210,340,000
Exports				
Portland cement				
United States	885,631	15,672,000	1,252,817	22,470,000
Other countries	2,214	59,000	1,122	38,000
Total	887,845	15,731,000	1,253,939	22,508,000
Cement and concrete basic products				
United States		9,688,000		16,214,000
Other countries		91,000		154,000
Total		9,779,000		16,368,000
Imports				
Portland cement, white				
United States	14,608	680,000	14,837	665,000
Belgium-Luxembourg	4,548	130,000	5,959	190,000
Japan	2,822	68,000	3,681	100,000
Denmark	-	-	55	2,000
Britain	100	4,000	-	-
Total	22,078	882,000	24,532	957,000
Cement, nes[3]				
United States	21,514	778,000	8,059	677,000
Britain	10,215	426,000	9,101	421,000
Denmark	-	-	927	40,000
West Germany	1,179	115,000	221	20,000
France	887	28,000	393	13,000
Total	33,795	1,347,000	18,701	1,171,000
Total cement imports	55,873	2,229,000	43,233	2,128,000

Table 1 (concl'd)

	1971		1972[p]	
	(short tons)	($)	(short tons)	($)
Refractory cement and mortars				
United States		1,840,000		2,170,000
Ireland		713,000		319,000
Britain		19,000		30,000
Denmark		12,000		24,000
Other countries		28,000		18,000
Total		2,612,000		2,561,000
Cement and concrete basic products, nes				
United States		254,000		349,000
Britain		78,000		151,000
West Germany		12,000		51,000
Belgium-Luxembourg		1,000		-
Total		345,000		551,000
Cement clinker				
United States	11,937	290,000	17,316	413,000

Source: Statistics Canada.
[1] Producers' shipments, plus quantities used by producers. [2] Includes small amounts of other cements.
[3] Includes grey portland, masonry, acid proof, aluminous and other specialty types of cement.
[p] Preliminary; nes Not elsewhere specified; . . Not available; – Nil.

220,000 tons a year during 1972 with the completion of a kiln addition at the Joliette, Quebec plant of Independent Cement Inc.; 10 companies continued to operate 24 plants with a total of 59 kilns available for production. Some plant expansions will be made during the period to 1975. During 1973 the new Bath, Ontario plant of Canada Cement Lafarge Ltd. is scheduled to come on stream at 1.1 million tpy capacity while Lake Ontario Cement Limited will increase capacity by 150,000 tpy and Canada Cement Lafarge's, Havelock, New Brunswick plant will improve capacity by 100,000 tpy. Through 1974 Lake Ontario will add an estimated 850,000 tpy to its plant capacity while St. Marys Cement Limited at Bowmanville, Ontario will add 350,000 tpy and Canada Cement Lafarge will add 500,000 tpy at its St-Constant, Quebec plant. By 1975 the extensive renovation to Canada Cement Lafarge's Exshaw, Alberta plant will result in a net increase of about 200,000 tpy to that facility.

Canadian industry and developments

Atlantic region. There are three cement manufacturing plants in the Atlantic provinces serving the markets in the immediate area by road, rail and water transportation routes. The plants represent 5.3 per cent of Canadian cement production capacity in a region having about 9 per cent of total population.

A plant located at Corner Brook, Newfoundland, established in 1951, is operated by North Star Cement Limited. Limestone and shale, raw materials for the dry process being used, are quarried in the immediate area and gypsum is purchased from The Flintkote Company of Canada Limited, which quarries gypsum at Flat Bay, about 60 miles south of Corner Brook. Shipments of portland cement are made by rail and by sea mostly to provincial markets. Production depends directly on construction activity. The values of building permits issued and of heavy construction awards were reduced in Newfoundland during 1972. It is unlikely that production of cement from this plant will increase greatly in the near future.

Nova Scotia's only cement manufacturing facility, a single-kiln, dry process plant incorporating the most modern analytical and control devices, was established in 1965 by Canada Cement Company, Limited (now Canada Cement Lafarge Ltd.) at Brookfield. Limestone at the plant site is chemically very close to a natural cement rock but variations in lime, alumina and iron content necessitate the addition of iron oxide, coal ash and high-calcium limestone, all of which are available nearby. Gypsum is purchased from the Milford quarry of National Gypsum (Canada) Ltd. about 25 miles south of Brookfield. Portland cement is marketed in bulk or package under the brand name "Maritime" Cement.

Table 2. Canada, cement production, trade and consumption, 1963-72

	Production[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
1962	6,878,729	219,164	26,525	6,686,090
1963	7,013,662	272,803	31,579	6,772,438
1964	7,847,384	297,669	32,680	7,582,395
1965	8,427,702	334,887	37,619	8,130,434
1966	8,930,552	407,395	50,615	8,573,772
1967	7,994,954	328,018	44,118	7,711,054
1968	8,165,805	366,506	51,500	7,850,799
1969	8,250,032	634,208	53,396	7,669,220
1970	7,945,915	566,521	97,191	7,476,585
1971	9,066,795	887,845	55,873	8,234,823
1972[p]	10,010,000	1,253,939	43,233	8,799,294

Source: Statistics Canada.
[1] Producers' shipments plus quantities, used by producers. [2] Does not include cement clinker. [3] Production plus imports less exports. [p]Preliminary.

During 1972 the value of Nova Scotia cement production showed little change from 1971 although the number of housing starts and the value of building permits issued increased substantially over the previous year. Heavy construction awards were increased in value over the same period.

Canada Cement Lafarge Ltd. also operates a cement-manufacturing plant at Havelock, New Brunswick. This plant, built in 1951 and expanded in 1966 by the addition of a second kiln, has a capacity of 350,000 tons a year and ships portland cement in bulk or in bags. The company plans to increase plant capacity with the addition of heavier grinding equipment and with larger storage facilities. Shipments in 1972 were up nearly 20 per cent over 1971. Housing starts and the value of building permits issued in 1972 in New Brunswick were greater than in 1971, as was the value of heavy construction awards.

Quebec. In the Province of Quebec, five companies operate a total of seven cement manufacturing plants. Regionally, the companies producing cement in Quebec, compete for the construction markets in the Montreal and Quebec City areas as well as for markets in more remote regions where major heavy construction projects are under way – the James Bay project, the Manicouagan project, and the iron ore development north of Port-Cartier. Of course preparations for the 1976 Olympics will add to activity in Montreal and the Ste-Scholastique airport project continues. In addition major export markets have been developed in the United States over the past few years for both cement and cement clinker. For the second straight year cement production in Quebec increased by nearly half a million tons over the previous year, increasing capacity utilization to about 60 per cent in 1972.

The Montreal East plant of Canada Cement Lafarge Ltd. at Pointe-aux-Trembles has been operated as part of the Canada Cement complex since it was acquired in 1909. Material from the adjacent quarry approximates a natural raw mix which requires only minor amounts of sand, iron oxide and high-calcium limestone for corrective purposes. Situated a mile from docking facilities on the St. Lawrence River, the plant has access to water transportation and ships to distribution warehouses in the Atlantic provinces and in areas bordering the Great Lakes as well as to local consumers. The plant capacity, 1.4 million tons a year, is second only to that of St. Lawrence Cement Company's Clarkson, Ontario plant, which has a capacity of 1.75 million tons. The Montreal plant is scheduled to be phased out some time after the company's new plant at Bath, Ontario comes on stream. Canada Cement Lafarge's plant at St-Constant, south of Montreal, has a capacity of 525,000 tpy with current plans to add a new kiln of 500,000 tpy capacity by 1974. The plant is modern, technically efficient and could conceivably replace some of the capacity of Canada Cement Lafarge's older Montreal East plant. The company's Hull operation is on the site where cement was first produced in Canada. From this location, areas of the Ottawa Valley are served. The Quebec government has indicated it will expropriate part of this property by mid-1974 and the entire property over the following 10 years.

Miron Company Ltd., with the second largest cement-producing capacity in the Montreal area, operates a dry process plant at St-Michel. The company also supplies concrete and other building materials to the construction industry and maintains a contracting division.

St. Lawrence Cement Company has a plant at Villeneuve near Quebec City capable of manufacturing about 790,000 tons of cement a year. Limestone and shale are available at the site, iron oxide and gypsum are brought in by truck and rail. Finished products include normal portland cement, medium heat of hydration cement, high early strength cement, low heat of hydration cement and masonry cement. Shipments are made in bulk or in bags by truck and by rail.

Independent Cement Inc. began construction of its cement-manufacturing plant at Joliette, Quebec, in 1965 and it went on stream in the fall of 1966 with a two-kiln operation capable of producing about 435,000 tons a year. A third kiln, adding about 220,000 tpy to plant capacity, started up in 1970 and in 1972 a fourth kiln of similar design was installed. This company has pursued an aggressive sales campaign and has captured a major share of the Montreal area markets.

Ciment Quebec Inc. was established in 1952 at St-Basile, 40 miles west of Quebec City, as a single-kiln operation. Two additional kilns were installed to boost production capacity to about 380,000 tons a year.

The value of building permits issued during 1972 in Quebec was higher than in 1971 and dwelling starts also increased.

Quebec, with nearly 30 per cent of the nation's population has 35 per cent of Canadian cement-producing capacity.

Ontario. Four companies operate a total of six cement-manufacturing plants in the Ontario region, serving industrial and urban growth areas in southern Ontario and shipping to points in Quebec and northern Ontario as well as exporting to the United States. One other company operates a clinker grinding plant.

The industrialized and population-intense region surrounding Lake Ontario and Lake Erie continues to grow and in so doing provides markets for cement in many engineering, commercial, industrial and residential building projects, all of which were greater in 1972 than in the previous year. The Ontario cement producers represent about 34 per cent of total production capacity in a region occupied by about 36 per cent of the total Canadian population. The industry operated at just over 74 per cent of capacity in 1972 and steady growth is indicated by the announced intentions to bring on stream an estimated additional 2.5 million tpy of capacity in the next few years.

Lake Ontario Cement Limited is Canada's largest cement exporter. The plant is located at Picton where favourable raw materials are situated adjacent to deep water, permitting comparatively inexpensive bulk shipments to be made to Great Lakes and St. Lawrence Seaway ports. Shipments, also made by truck and by rail to domestic markets, were at an all-time high in 1972. The company is planning a plant expansion to meet the expected growth in demand for cement and concrete products.

The Belleville plant of Canada Cement Lafarge Ltd. is one of the original operations grouped to form the Canada Cement Company in 1909. Many equipment changes have been made over the years and the present three-kiln, wet process is capable of producing about 770,000 tons of cement a year. Intentions are to phase out this operation with completion of the Bath plant. However, demand for cement in the next few years could extend the productive life of this facility. Located on deep water, the plant is served by ship as well as by rail and truck haulage.

Canada Cement Lafarge operates a plant at Woodstock, Ontario, capable of producing about 600,000 tpy from a two-kiln, wet process. The plant was constructed in 1956 to serve the developing area of southwestern Ontario. Clay overburden from the limestone quarry is of a quality that can be utilized in manufacturing masonry cement, high early strength cement and normal portland cement.

St. Lawrence Cement Company constructed its Clarkson, Ontario, plant in 1957 and with the expansion to 1.75 million tons a year in 1968, it became Canada's largest producing plant. The plant now combines a wet and dry process and it features the largest suspension preheater kiln in North America, an Aerofall mill 27 feet in diameter by 8 feet in length, rated at 400 tons an hour of 8-inch stone, and what has been heralded as the world's largest mill, 18 feet in diameter by 72 feet in length, a gearless drive system in which one end of the mill itself is the rotor within a 32-foot diameter stator, all part of an 8,700 hp synchronous motor.

Limestone for the plant is brought in by boat from Ogden Point, 100 miles east of Toronto on the north shore of Lake Ontario. A new mile-long, overhead, covered conveyor is used to transport stone from the lake carriers to the plant. Gypsum is trucked from producers in southwestern Ontario. The market area for finished cement product is mainly the Toronto-Hamilton strip and southern Ontario served by rail and truck deliveries. Large quantities of clinker are exported to United States points.

St. Marys Cement Limited operates two plants in Ontario. The original plant at St. Marys was constructed in 1912 to serve the Toronto area. It has been expanded and modernized over the years and remains a major producer capable of turning out about 750,000 tons a year. A new and highly automated plant was built at Bowmanville during 1967 and 1968. First shipments were made in January 1969. The plant is favourably located with respect to the major marketing area of metropolitan Toronto and is capable of producing 350,000 tpy from raw material at the site. Plant expansion to 700,000 tpy is under way. Shipments are made by truck and by rail.

Medusa Products Company of Canada, Limited, of Paris, Ontario, grinds a white clinker imported from the Medusa plant at York, Pennsylvania. The white cement is sold mainly in Ontario.

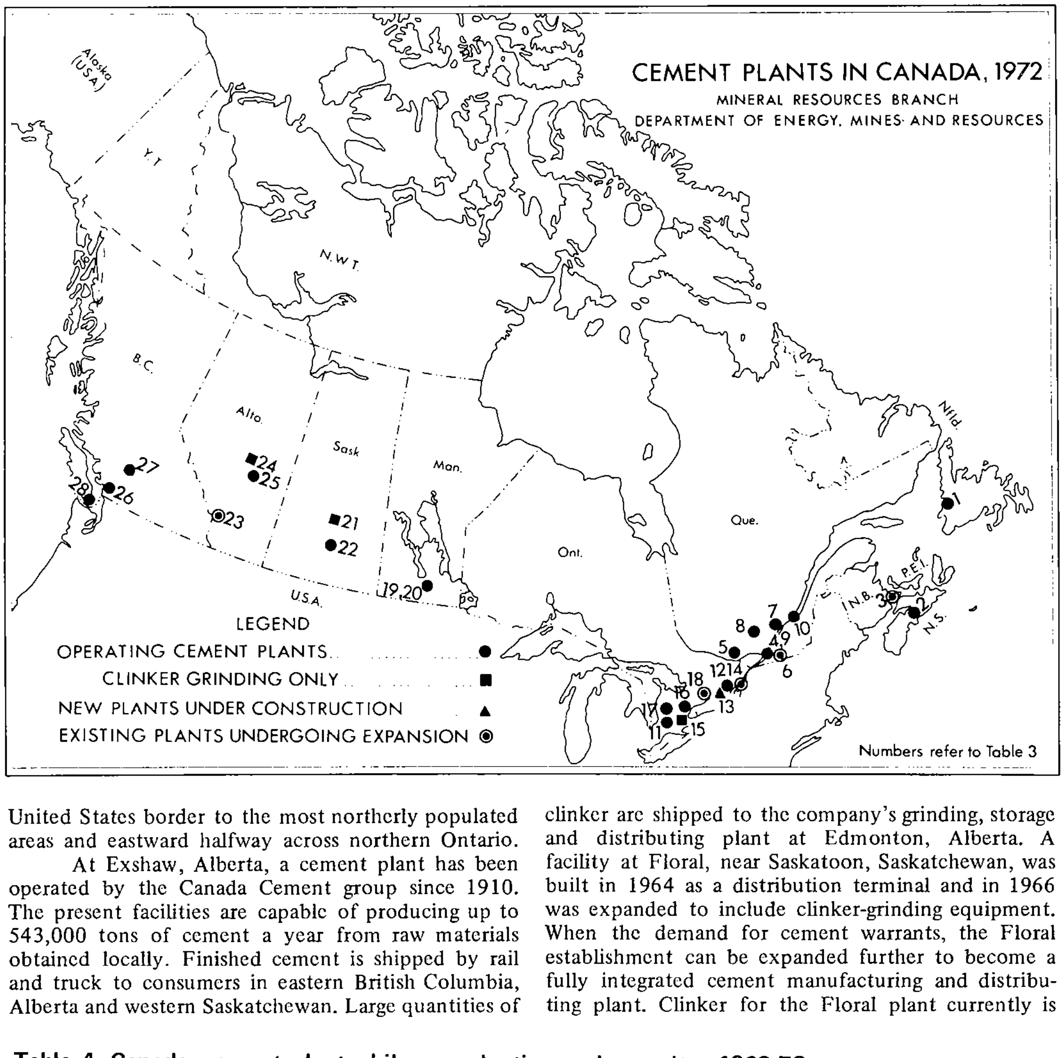
Prairie region. Two companies, Canada Cement Lafarge Ltd. and Inland Cement Industries Limited, operate a total of five clinker-producing plants in the Prairie region along with two clinker-grinding plants. The region accounts for 15.6 per cent of Canadian cement-producing capacity exclusive of the grinding plants and during 1972 produced at approximately 70 per cent of that capacity. In general the construction industry held its own during the year as recovery from a relatively poor 1970 continued.

Canada Cement Lafarge Ltd. operates a plant at Fort Whyte, near Winnipeg, Manitoba. The original facility has been enlarged and rebuilt several times and is today a highly efficient plant capable of producing 630,000 tons of cement a year. High-calcium limestone is obtained from the company's quarry at Steep Rock on the shore of Lake Manitoba, gypsum is purchased from Silver Plains, silica from Beausejour and clay from Fort Whyte. Products include portland cement, sulphate-resisting cement, oil well cement and masonry cement for a market area extending from the

Table 3. Cement plants – approximate annual capacities, 1972

Company	Plant Location	Process	Capacity
			(short tons)
Atlantic region			
1. North Star Cement Limited	Corner Brook, Newfoundland	dry	175,000
2. Canada Cement Lafarge Ltd.	Brookfield, N.S.	dry	262,000
3. Canada Cement Lafarge Ltd.	Havelock, N.B.	dry	350,000[1]
Total Atlantic region			787,000
Quebec			
4. Canada Cement Lafarge Ltd.	Montreal	wet	1,400,000[2]
5. Canada Cement Lafarge Ltd.	Hull	wet	210,000
6. Canada Cement Lafarge Ltd.	St-Constant	dry	525,000[3]
7. Ciment Quebec Inc.	St-Basile	wet	380,000
8. Independent Cement Inc.	Joliette	dry	875,000
9. Miron Company Ltd.	St-Michel	dry	1,050,000
10. St. Lawrence Cement Company	Villeneuve	wet	787,500
Total Quebec region			5,227,500
Ontario			
11. Canada Cement Lafarge Ltd.	Woodstock	wet	595,000
12. Canada Cement Lafarge Ltd.	Belleville	wet	770,000
13. Canada Cement Lafarge Ltd.	Bath	dry	1,100,000[4]
14. Lake Ontario Cement Limited	Picton	dry	875,000[1]
15. Medusa Products Company of Canada, Limited	Paris	grinding only	
16. St. Lawrence Cement Company	Clarkson	wet/dry	1,750,000
17. St. Marys Cement Limited	St. Marys	wet	743,000
18. St. Marys Cement Limited	Bowmanville	wet	350,000[1]
Total Ontario region			5,083,000
Manitoba			
19. Canada Cement Lafarge Ltd.	Fort Whyte	wet	630,000
20. Inland Cement Industries Limited	Winnipeg	wet	350,000
Saskatchewan			
21. Canada Cement Lafarge Ltd.	Floral	grinding only	
22. Inland Cement Industries Limited	Regina	dry	227,500
Alberta			
23. Canada Cement Lafarge Ltd.	Exshaw	wet	543,000[5]
24. Canada Cement Lafarge Ltd.	Edmonton	grinding only	
25. Inland Cement Industries Limited	Edmonton	wet	577,500
Total Prairie region			2,328,000
British Columbia			
26. Canada Cement Lafarge Ltd.	Lulu Island	wet	612,500
27. Canada Cement Lafarge Ltd.	Kamloops	dry	210,000
28. Ocean Construction Supplies Limited	Bamberton	wet	700,000
Total British Columbia region			1,522,800
Total capacity (59 kilns)			14,948,000

Source: Published data and company communication.
[1] Increase scheduled for 1973. [2] To be phased out. [3] Capacity to be doubled by 1974. [4] Not included in total. Under construction. Scheduled for 1973. [5] Increase scheduled for 1975.



United States border to the most northerly populated areas and eastward halfway across northern Ontario.

At Exshaw, Alberta, a cement plant has been operated by the Canada Cement group since 1910. The present facilities are capable of producing up to 543,000 tons of cement a year from raw materials obtained locally. Finished cement is shipped by rail and truck to consumers in eastern British Columbia, Alberta and western Saskatchewan. Large quantities of clinker are shipped to the company's grinding, storage and distributing plant at Edmonton, Alberta. A facility at Floral, near Saskatoon, Saskatchewan, was built in 1964 as a distribution terminal and in 1966 was expanded to include clinker-grinding equipment. When the demand for cement warrants, the Floral establishment can be expanded further to become a fully integrated cement manufacturing and distributing plant. Clinker for the Floral plant currently is

Table 4. Canada, cement plants, kilns, production and capacity, 1968-72

	Plants	Kilns	Approximate Annual Capacity[1]	Production	Capacity Utilization
			(tons)	(tons)	(%)
1972	24	59	14,948,000	9,962,455	67
1971	24	58	14,729,000	9,326,312	63
1970	24	58	14,729,000	7,945,915	54
1969	23	56	14,301,000	8,250,032	58
1968	23	56	14,301,000	8,165,805	61

Source: Data supplied by companies to Mineral Resources Branch.
[1] Adjusted.

Table 5. Canada, destination of domestic cement shipments[1], 1972

	(short tons)
Ontario	3,539,932
Quebec	2,110,123
Rest of Canada	2,779,118
Canada, total	8,429,173
Exports	1,343,996
Total shipments	9,773,169

Source: Statistics Canada.
[1]Special compilation. Direct sales from producing plants.

obtained from Fort Whyte. Major improvements under way and planned for the Exshaw plant will result in a net increase in production capacity of about 40 per cent to 700,000 tons a year. A new quarry site will be developed requiring the relocation of several roads and structures in Exshaw.

Inland Cement Industries Limited, a Genstar Limited subsidiary, operates three cement-manufacturing plants – one in Winnipeg, Manitoba, one in Regina, Saskatchewan, and one in Edmonton, Alberta. The Winnipeg plant is the most recent addition to the company's facilities, having come on stream in 1965 to increase the company's total production capacity to over 1 million tons a year. A limestone quarry at Mafeking, Manitoba, near the Manitoba–Saskatchewan border supplies limestone to the Regina plant while the Winnipeg plant is supplied from Steep Rock. The Edmonton plant is supplied from Cadomin, Alberta, by a 5,000-ton unit-train which is part of a total, automated, materials-handling system. Other raw materials are obtained close to the plant sites. A market area stretching east to the Lakehead and west to central British Columbia is served by Inland's facilities.

Pacific region. Construction in British Columbia during 1972 advanced at a slower pace than had been anticipated but there are prospects of greater developments during the next few years. This trend will be reflected in cement production from each of the three plants which represent in total 10 per cent of the nation's productive capacity. The industry operated at less than 60 per cent of capacity in 1972.

Canada Cement Lafarge Ltd. produces cement at Richmond on Lulu Island near Vancouver, British Columbia, using limestone barged down the Strait of Georgia from a quarry at Vananda on Texada Island. The plant was built in 1958 and later the capacity was doubled to the present 612,000 tons a year. A new plant with a capacity of over 210,000 tpy began production in 1970 at Kamloops, British Columbia.

Ocean Cement & Supplies Ltd. quarried limestone at Bamberton on Vancouver Island for cement manufacture and for use as an aggregate. The cement plant has a capacity of about 700,000 tons a year.

In December 1971, Genstar Limited announced that agreement had been reached with Associated International Cement Ltd. (A.I.C.), a wholly owned subsidiary of Associated Portland Cement Manufacturers Ltd. of London, England, for the purchase of A.I.C.'s shares of Ocean Cement & Supplies Ltd. The block represented 51.5 per cent of Ocean Cement's outstanding shares. Inland Cement Industries Limited and Ocean Cement & Supplies Ltd. are now operated as a cement division of Genstar.

Early in 1973 eight companies operating in the cement-concrete industry in British Columbia were charged in provincial court under the Combines Investigation Act of illegally lessening and preventing competition in the supply and sale of cement and ready-mix concrete.

N.B. Cook Corp. Ltd. announced, in February 1973, its intention to develop a $20 million, 300,000 tpy cement plant on a 55-acre water-front site in Richmond municipality.

Markets and trade

Cement markets are regional in scope and are centred in developing or growing urban areas where construction activity is concentrated, or in areas where mining or heavy engineering construction projects are being performed. The market area influenced by a given cement-producing plant is dependent on the amount of transportation cost that the selling price can absorb. A potential large volume of sales could warrant a secondary distribution terminal; water transportation to a distribution system could extend a plant's market area even farther. Because raw materials for cement manufacture are available in nearly all areas, most countries can supply their own cement requirements if the market volume warrants a plant. Few countries rely entirely on imports for their cement needs. Some countries do, however, rely heavily on export markets for their cement production in order to operate facilities economically.

Specialty cements, such as white cement, are transported greater distances than ordinary grey portland cement, when the transportation costs do not represent as high a proportion of the landed price and when quantities are generally much smaller than for portland cement.

Cement from plants in the United States and Canada is traded between the two countries where competition and tariffs permit, Canada being a net exporter in this regard. Canadian market areas are reflected in the distribution of shipments from Canadian producers, shown in Table 5.

Although cement is used mainly in the construction industry, significant amounts are used in the mining industry to consolidate backfill where mining methods dictate. Amounts so used have grown from about 5,000 tons in 1960 to a reported 231,000 tons

Table 6. Canada, mineral raw materials[1] used by the cement industry

Commodity	1970	1971
	(short tons)	
Shale	839,357	945,224
Limestone	11,892,697	13,422,375
Gypsum	352,788	399,915
Sand	218,519	161,767
Clay	1,075,864	1,173,700
Iron oxide	80,987	81,503

Source: Statistics Canada.
[1]Includes purchased materials and materials produced from own operations.

in 1970, the increase being related to the mechanization of backfilling techniques and to research conducted with support from National Research Council's Industrial Research Assistance Program. In 1971, the amount so used was recorded as 219,041 tons.

The use of a gypsum-free portland cement in a new patented process for the production of cold-bonded iron ore pellets offers an interesting market possibility.

Outlook

Construction in Canada will continue to show an annual increase in value and cement producers will have to compete with all other building materials to obtain their share of the construction dollar. Not only is practical research in the use of cement-concrete needed, but effective advertising and public relations must be used to encourage acceptance of modular construction at a time when reasonably priced, attractive and convenient housing units are in short supply. In general, modest gains are expected in the near term with activity across the country expected to range from promising to cautious. A shift of emphasis from Ontario to Quebec and the Atlantic region has been forecast by Canadian Construction Association officials.

The cement industry in Canada is capable of meeting the immediate demands on it and is in a position to expand in anticipation of even greater demand.

New plants are being built and existing ones are being expanded utilizing modern equipment and techniques of manufacture, and new plant locations are suitably situated with respect to both resource material and markets. The expense of adapting older facilities to meet newly imposed environmental control regulations can contribute to a decision in favour of a new plant, and has, in the United States, forced a

Table 7. Planned capacity increases cement plants

Company	Location	Net Increase	Expected Completion Date	Approximate Cost	Remarks
		(tons/year)		($ million)	
New Brunswick					
Canada Cement Lafarge Ltd.	Havelock	100,000	1973	..	Additional grinding and storage capacity
Quebec					
Canada Cement Lafarge Ltd.	St-Constant	500,000	1974	30	New kiln
Ontario					
Canada Cement Lafarge Ltd.	Bath	1,100,000	1973	50	Complete new plant
Lake Ontario Cement Limited	Picton	1,000,000[e]	1974	50	New kiln and modifications to present plant
St. Marys Cement Limited	Bowmanville	350,000	1974	15	New kiln
Alberta					
Canada Cement Lafarge Ltd.	Exshaw	200,000	1975	30	New kiln, modernization of existing plant and new quarry development

[e]Estimated; .. Unavailable.

Table 8. Cement, world production and capacity

Country	Annual Capacity^e 1972	1971	1972^e
	(thousand short tons)		
United States (incl. Puerto Rico)	86,800	80,317	84,800
Canada (shipments)	14,900	9,067	10,000
Other North America (except Cuba)	15,000	11,664	12,800
Total, North America	116,700	101,048	107,600
South America	33,500	27,180	28,500
Europe (free)	235,800	193,716	203,400
Asia (free)	157,000	122,252	134,500
Africa	26,400	20,788	22,500
Oceania	7,800	6,193	6,600
Communist countries (except Yugoslavia)	224,000	178,963	196,900
World total	801,200	650,140	700,000

Data source: U.S. Bureau of Mines, Commodity Data Summaries, January 1973.
^{e}Estimate.

number of plant closures. Continued diversification and vertical integration by cement producers will eventually result in the write-off of some comparatively inefficient production capacity as the emphasis on a cement-concrete industry increases. Although individual companies continue to conduct research relative to cement production, much experimentation concerning the use of cement and concrete is done through the Portland Cement Association (PCA), an industry-supported, nonprofit organization whose purpose is to improve and extend the uses of cement and concrete through scientific research and engineering fieldwork. The Association is active in all parts of Canada and can offer detailed information on concrete use, design and construction from its regional offices.

Specifications

Portland cement used in Canada should conform with the specifications of CSA Standard A5 – 1971 published by the Canadian Standards Association. This standard covers the five main types of portland cement as follows: Normal, Moderate, High Early Strength, Low Heat of Hydration, and Sulphate-Resisting Portland cements. Masonry cement produced in Canada should conform to the CSA Standard A8 – 1970.

The cement types manufactured in Canada and not covered by the CSA standards generally meet the appropriate specifications of the American Society of Testing and Materials (ASTM).

Cembureau, The European Cement Association, has published *Cement Standards of the World – Portland Cement and its Derivatives*, in which standards are compared. Cembureau's *World Cement Directory* lists production capacities, by company and by country.

World review

Preliminary data on world cement production indicate that over-all capacity utilization was approximately 88 per cent during 1972, a much more favourable position than in 1971. World production was close to 700,500,000 tons, up between 7 and 8 per cent from 1971. Even greater additions to production capacities

Table 9. World production of cement, 1961 and 1971

	1961	1971	Increase
	(thousand short tons)		
U.S.S.R.	56,217	110,557	97
United States	63,662	78,321	23
Japan	27,156	65,543	141
West Germany	29,921	45,212	51
Italy	19,876	35,040	76
France	16,954	31,905	88
Britain	15,847	19,722	24
Spain	7,306	18,730	156
India	9,087	16,455	81
Poland	8,117	14,418	78
China	8,817	–	
Canada	6,205	9,066	46
Czechoslovakia	5,889	8,770	49
Other countries	92,484	159,643	
Total	367,538	614,382[1]	

Source: Statistics Canada; U.S. Bureau of Mines Minerals Yearbook, 1963 for 1961; United Nations Monthly Bulletin of Statistics January, 1973.
–Not available.
[1]Excluding China.

Table 10. World cement production, per capita, 1961 and 1971

	1961	1971	Increase
	(lb)	(lb)	(%)
West Germany	1,108	1,528	38
Italy	797	1,296	63
Japan	577	1,252	117
France	735	1,245	69
Czechoslovakia	854	1,210	42
Spain	478	1,098	130
U.S.S.R.	516	902	75
Canada	679	841	24
Belgium	1,141	777	-32
United States	693	757	9

than those witnessed during the past few years will be needed to meet demand in many developing countries. The following items are indicative of trends in the regions noted but in no way represent a total coverage. Because of the direct relationship of cement-concrete-construction, the production and, more particularly, the consumption of cement can be monitored as an indication of a country's rate of development.

Europe. Most European countries have indicated continuous growth in cement-producing capacity to supply a steadily increasing demand. West Germany leads in production with Italy, France, Spain and Britain following in that order. Both West Germany and Greece increased production by nearly 14 per cent during 1972, Spain was up by over 10 per cent, Italy by over 8 per cent and Britain by only about 1 per cent.

In Greece, Titan Cement Company operated from facilities expanded in 1971 and continued its expansion program which will eventually give the company a capacity of 3 million tons a year.

Greek Concrete Cement Co., Athens, was formed by four of the nation's cement producers to produce ready-mix at four locations. Of the $3 million invested, 41 per cent came from General Cement Co. S.A., 41 per cent from Titan Cement Co. S.A., 10 per cent from Halkis Cement Co. S.A., and 8 per cent from Halps Cement Co. S.A.

The Italian cement industry is in crisis, according to AITEC (Italian Technical-Economic Cement Association) as a result of a number of existing conditions including a decline in the building industry, utilization of 77 per cent of capacity, and controlled cement prices.

In Britain and Ireland noticeable trends have been established in cement distribution patterns whereby production has been more concentrated at larger works and the use of distribution terminals has grown.

Important producers in the communist bloc are the U.S.S.R. with over 100 million tpy followed by Poland with nearly 14 million tons, Romania with over 9 million tons and Czechoslovakia with over 8 million tons.

Table 11. Canada, production of concrete products

	1971	1972[p]
Concrete bricks (no.)	109,503,448[e]	133,362,069
Concrete blocks (except chimney blocks)		
Gravel (no.)	171,917,492[r]	174,004,183
Other (no.)	35,288,949	41,316,111
Concrete drain pipe, sewer pipe, water pipe and culvert tile (st)	1,508,520	1,510,442
Concrete, ready mix (cu yd)	15,047,226	15,520,378

Source: Statistics Canada.
[r]Revised; [p]Preliminary.

Asia. Although cement production capacity in Japan totals over 90 million tpy, production is closer to 65 million tons, a situation giving rise to fears of a cement shortage as demand is forecast to reach 100 million tpy by 1975, principally as a result of increased public works. Production for 1972 did not increase by more than 5 per cent although demand was expected to rise by 10 per cent.

In India various expansion programs to increase production capacity to 21.2 million tpy by 1973 are currently under way. Although some sources believe demand will be only about 15 million tons at that time, projections indicate production for 1973 in excess of 15 million tons.

Polimex Foreign Trade Enterprise of Poland has signed a contract with the Iraqui State Organization for Design and Construction for the supply of machinery and equipment and the assembly and commissioning of a cement plant producing 700 tons a day. The plant will be built near Baghdad and commissioned late in 1974.

Expansion of the cement plant at Samawa, is expected to be completed early in 1973. Annual output will rise by 500,000 tons to 900,000 tons. Iraq's present cement output is 1,400,000 tpy, 1,100,000 tons of which is for domestic use.

Tjibinong Cement Co. will construct Indonesia's largest cement plant near Djakarta to supply a region currently served mainly by imported cement. The single-kiln dry-process plant will have a capacity of 500,000 tons a year and is designed to permit doubling capacity as warranted. Distribution facilities are to be built at Djakarta.

In Sumatra, a 400,000 tpy cement clinker plant is to be built near Bohorok to be coupled with a grinding plant 90 kilometres away at Belawan, all by P.T. Sumatra Cement. Current demand for cement in Sumatra is close to 400,000 tons a year and to meet growing needs P.N. Padang Cement is rehabilitating while importing over 10,000 tons a month.

Thailand cement production increased nearly 10 per cent in 1972. Three new plants are expected to increase capacity by over 1 million tons a year and create a short-lived surplus.

North America. To meet the projected demands of industrial expansion, in the late 1950's many cement companies added to their production capacities with the result that the North American industry developed a total capacity in excess of that required to meet the demand. The cement industry had then to 'sell' its product by providing services and technical assistance to consumers and by researching new and competitive construction uses for concrete. Vertical integration, diversification and mergers, although always a part of the cement industry, have become more common on the North American scene.

About 16 per cent of world cement production comes from North America, with the United States contributing nearly 80 per cent of the total and Canada and Mexico following in that order. Numerous plant changes and additions have been announced throughout the industry in North America. Virtually all plants are undergoing some modernization and improvement of dust-collecting facilities because of new or anticipated pollution control standards and a few plants in the United States have cited this as a reason for closure. Canada enjoys a surplus capacity at this stage and with about 3.0 million tpy additional capacity planned, could be in a favourable export position during the next few years.

In the United States the current cement shortage is generally credited to three basic problems: the return on investment is too low to attract new capital for new operations, the Price Commission set controls on cement prices based on a three-year period when profit margins were the lowest in many years and pollution control regulations have made it uneconomic to update equipment, the alternative has been to close some plants. Air pollution standards for portland cement plants were published in the United States Federal Register, December 23, 1971 – particulate matter limits are: from the kiln, 0.30 pound per ton of feed; from the clinker cooler, 0.10 pound per ton of feed to the kiln; no visible emissions from individual sources within the plant that exceed 10 per cent opacity.

Capacity changes within the cement industry in the United States during 1972 included the following: Arizona Portland Cement Co. at Rillito, Arizona from 0.564 million tpy to 0.790 million; Gifford-Hill Portland Cement Co. at Midlothian, Texas from 0.564 million tpy to 0.846 million; Texas Industries Ltd. at the same location from 0.902 million tpy to 1.203 million; Hawaiian Cement Corp. Division of American Cement Corp. at Oahu, Hawaii from 0.188 million tpy to 0.470 million.

In what might become a popular means of supplementing company cement output, the Cement Division of Ideal Basic Industries, Inc. has contracted with C.A. Venezolana de Cementos of Venezuela for over 500,000 tons of cement for delivery to Ideal's customers in southeastern states. General Portland, Inc., using another tack, was to acquire 49 per cent ownership of Cementos Anahuac del Golfo, S.A. of

Table 12. Canada, value of construction, 1971-72

	1971			1972[1]		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
			(thousands of dollars)			
Newfoundland	226,762	312,453	539,215	275,216	319,460	594,676
Nova Scotia	265,691	200,320	466,011	280,495	245,969	526,464
New Brunswick	201,188	148,660	349,848	209,367	181,492	390,859
Prince Edward Island	40,102	17,286	57,388	46,796	20,320	67,116
Quebec	2,032,854	1,219,735	3,252,589	2,198,924	1,318,464	3,517,388
Ontario	3,713,900	1,909,699	5,623,599	3,739,255	2,019,577	5,758,832
Manitoba	375,464	321,998	697,462	405,725	358,170	763,895
Saskatchewan	226,278	297,608	523,886	237,029	306,341	543,370
Alberta	804,260	959,935	1,764,195	837,611	990,408	1,828,019
British Columbia, Yukon, Northwest Territories	1,257,003	1,116,170	2,373,173	1,241,013	1,109,282	2,350,295
Canada	9,143,502	6,503,864	15,647,366	9,471,431	6,869,483	16,340,914

Source: Statistics Canada.
[1]Intentions.

Mexico whose production is destined for Florida and Texas.

Puerto Rican Cement Co., Inc. and San Juan Cement Co. each announced plant capacity increases during 1972.

South America. The Brazilian cement industry expects to produce 21 million tons a year in 1975, requiring investments of more than $500 million. Current production is 9 million tpy.

A dry process, 550,000 tpy cement plant is being added to the facilities of Companhia Cimento Vale do Paraíba at Pedra do Sino, Carandai, Minas Gerais. The Export-Import Bank of the U.S. is assisting in financing the $17 million project.

Also planned for the Minas Gerais area is a 1 million tpy plant sponsored by the Leiria Group, Portugal while a new plant near the Brazilian capital was expected to commence operations in 1972 at about 200,000 tpy and to increase to 350,000 tpy by 1975.

The Cia de Cemento Sul Paulista will construct a plant at Iporanga (Sao Paulo) to produce 700,000 tpy by 1973 and Cemento Itau do Parana will build a 1,000-ton-a-day plant at Rio Branco do Sul (Parana).

Africa. Construction of a cement plant in Somali by North Korea is being planned. A joint Somali-Korea committee was making an economic evaluation of the project at the end of 1971, and construction was to start in 1972. The site will be either Berbera or Mogadishu.

The production capacity of the cement plant at Homs, Libya is to be expanded to 1,000 metric tons per day. A contract for the project has been awarded to a consortium of German firms – Krupp, Siemens and Sueas.

The cement industry in South Africa plans to add over 2 million tons of capacity. Production is currently about 6 million tpy, up slightly from 1971 totals.

The Moroccan government has provided capital for a 50 per cent interest in Lafarge-Moroc. The funds will be used to expand the firm's Casablanca plant to about 1.1 million tons a year.

In West Africa a growing demand for cement for basic heavy construction has lead to the development of limestone deposits near Lome in Togo to produce 1 million tpy of cement clinker. To carry out the project a joint company, Société des Ciments de l'Afrique de l'Ouest (CIMAO), was formed in 1969 by the governments of Togo and Ivory Coast in partnership with Lambert Frères, each with one third interest. CIMAO's clinker-crushing plant near Lome, with a capacity of 100,000 tpy, began operations in July 1971 using imported clinker.

In Zaïre a German firm, Klockner-Industrie-Anlagen, began work in mid-1971 on a cement plant in Kongo-Central which is expected to achieve a total production of 1.5 million metric tons within the first five years of operation. Zaïre suspended the export and business-income taxes on all exported cement for two years to improve the competitive position of Zaïre cement in traditional export market countries.

Oceania. Production of cement in Oceania is mostly from Australia where 16 plants have a total capacity of over 5 million metric tons. Australia's consumption of cement is increasing at about 6 per cent a year and is close to, if not above, the United States and Canada on a per capita basis.

Prices

Average price per ton of Canadian shipments:

1971	$21.09
1972[p]	$21.01

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(¢)	(¢)	(¢)
29000-1	Portland and other hydraulic cement, nop; cement clinker per 100 lb	free	free	6
29005-1	White, nonstaining portland cement, per 100 lb	4	4	8

Tariffs (concl'd)

United States

Item No.		On and After January 1 1971	1972
		(¢ per 100 lb incl. weight of container)	(¢ per 100 lb incl. weight of container)
511.11	White, nonstaining portland cement	1.5	1
511.14	Other cement and cement clinker	0.4	free
		(%)	(%)
511.21	Hydraulic cement concrete	1	free
511.25	Other concrete mixes	9	7.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated), 1972, TC Publication 452.

Chromium

D. D. BROWN

Chromium ore of all grades was in ample supply during 1972; estimated world production was 7.2 million short tons. About three quarters of world supply was derived from five countries – the U.S.S.R., Republic of South Africa, Philippines, Turkey and Rhodesia. Ferrochrome was also in oversupply and United States producers reduced prices to meet lower-priced South African imports.

Canada's chromium supply is imported from offshore sources and from the United States as re-exported material. There has been no mine production from Canadian deposits since 1949 nor are prospects for future production encouraging unless technological advances make economic the high-tonnage but low-grade deposits found in the Bird River area of southeastern Manitoba. Former Canadian production of chromite has been limited, intermittent and related primarily to periods of national emergency, such as during the two World Wars. Consumption of chromite in Canada is for metallurgical and refractory manufactures; there is no manufacture of chromium chemicals.

Chromium ferroalloys are manufactured in Canada only by Union Carbide Canada Limited, Metals and Carbon Division. Union Carbide has plants at Beauharnois, Quebec, and Welland, Ontario. The company manufactures high-carbon ferrochrome, charge chrome and ferrochrome silicon by electric furnace reduction of chromite at the Welland, Ontario plant. A wide range of chromium ferroalloys are also imported.

Consumers of ferrochrome in Canada include Atlas Steels Division of Rio Algom Mines Limited; Colt Industries (Canada) Ltd.; Fahralloy Canada Limited; and The Steel Company of Canada, Limited.

Among the manufacturers of chromite-bearing firebrick cements and mortars are: Dresser Industries Canada, Ltd.; Kaiser Refractories Company, Division of Kaiser Aluminum & Chemical Canada Limited; and Quigley Company of Canada Limited.

Outlook

Noncommunist world chromite reserves, predominantly in the Republic of South Africa and Rhodesia, are more than sufficient to supply forecast noncommunist world demand that is expected to grow at about 3½ per cent annually into the 1980's. These countries can be expected to favour increasing exports of ferrochrome over the less profitable unprocessed chromite ore. Because of the development of controlled atmosphere decarburization processes that minimize the oxidation and loss of chromium in the electric furnace production of stainless steel, less expensive high-carbon ferrochrome and charge-grade ferrochrome are likely to be more extensively used than the more expensive low-carbon ferrochrome and ferrochrome-silicon. In recent years, producers of stainless steel have turned to South Africa for these ferroalloys. Demand for metallurgical ore will be closely linked to demand for stainless and alloy steels and increasing world use of lower-grade South African Transvaal ores for metallurgical purposes appears likely.

United States

United States, the leading importer and consumer of chromite, relies on imported supplies. U.S. imports of chromite in 1972 were approximately 1.06 million short tons and consumption was 1.14 million tons compared with 1.30 million tons imported and 1.09 million tons consumed the previous year. The metallurgical industry used 63.9 per cent of total 1972 consumption, the refractory industry used 19.5 per cent and the chemical industry 16.6 per cent. The largest supplier of chromite to the U.S. was the U.S.S.R. with 40.9 per cent followed by South Africa, 23.2 per cent and Philippines, 12.4 per cent. The ban on chromium ore (chromite) from Rhodesia into the United States was officially lifted on January 1, 1972, following the period of United States' participation in the United Nations' economic sanctions against Rhodesia, first imposed in 1967. Rhodesia supplied 8.8 per cent of United States chromite imports in 1972.

During 1972, the United States General Services Administration sold, by negotiation, 12,556 long tons of chemical-grade chromite and 13,620 long tons of refractory-grade chromite from stockpile. The stockpile contained 2.11 million tons of metallurgical-grade chromite, 1.18 million tons of refractory-grade and 971 thousand tons of chemical-grade ore on June 30, 1972.

World production and types of ore

World production of chromite increased from 5.64 million short tons in 1969 to 6.97 million in 1971. The main sources of metallurgical-grade chromite are the U.S.S.R., Rhodesia and South Africa. Of these

Table 1. Canada, chromium trade and consumption, 1971-72

	1971		1972[p]	
	(short tons)	($)	(short tons)	($)
Imports				
Chromium in ores and concentrates				
United States	15,581	1,331,000	12,731	1,005,000
Cyprus	3,448	324,000	2,778	265,000
Philippines	2,856	204,000	3,407	254,000
South Africa	2,560	118,000	2,209	108,000
Mozambique	–	–	3,383	80,000
Ireland	1,437	182,000	220	30,000
U.S.S.R.	6,834	670,000	–	–
Total	32,716	2,829,000	24,728	1,742,000
Ferrochromium				
South Africa	32,177	6,729,000	11,413	3,110,000
United States	2,524	1,071,000	3,148	1,113,000
Japan	4,199	1,733,000	220	85,000
Sweden	422	197,000	190	55,000
Norway	445	165,000	195	50,000
West Germany	29	7,000	38	22,000
France	110	50,000	–	–
Total	39,906	9,952,000	15,204	4,435,000
Chromium sulphates, basic for tanning				
United States	888	225,000	1,069	263,000
Japan	360	60,000	310	59,000
Britain	140	30,000	120	26,000
Total	1,388	315,000	1,499	348,000
Chromium oxides and hydroxides				
Britain	76	59,000	478	333,000
United States	171	122,000	485	325,000
U.S.S.R.	–	–	132	65,000
Italy	–	–	39	21,000
West Germany	73	49,000	16	14,000
Belgium and Luxembourg	12	7,000	19	10,000
Japan	441	211,000	5	2,000
Other countries	6	3,000	–	–
Total	779	451,000	1,174	770,000
Chrome dyestuffs				
West Germany	12	46,000	22	91,000
Switzerland	19	26,000	31	51,000
United States	48	73,000	28	50,000
Britain	9	18,000	7	15,000
Japan	7	12,000	6	11,000
Netherlands	4	7,000	3	7,000
Italy	1	1,000	1	3,000
France	1	3,000	–	–
Total	101	186,000	98	228,000
Consumption				
Chromite	61,313	. .	. .	. .

Source: Statistics Canada.
[p]Preliminary; – Nil; . . Not available.

countries, Rhodesia and South Africa have the largest reserves of chemical-grade ores. The principal sources of high-alumina refractory-grade chromite are the Philippines and Turkey.

The only commercially important ore of chromium (Cr) is chromite ($FeO{\cdot}Cr_2O_3$) which has a theoretical Cr_2O_3 content of 68 per cent. Chromite ores usually deviate from the theoretical composition and contain varying amounts of magnesium and aluminum according to the general formula (Fe, Mg) O (Cr, Al, $Fe)_2O_3$. The better quality metallurgical-grade chromite ores are hard, lumpy ores containing 46 per cent or more Cr_2O_3 and having a chromium-to-iron ratio (Cr:Fe) of three to one (3:1) or more.

Specifications for refractory-grade chromite are not as rigid as for metallurgical chromite. The refractory industry uses chromite averaging about 35 per cent Cr_2O_3. The iron and silica content should not be over 12 per cent and 6 per cent, respectively; chromic oxide (Cr_2O_3) and alumina (Al_2O_3) combined should be in the range of 57-63 per cent. The ore should be hard and lumpy and about -10 mesh in size. Chromite fines are suitable for the manufacture of refractory brick cement and chrome-magnesite brick. Friable chromite ores containing 44 to 50 per cent Cr_2O_3 and a maximum of 26 per cent Fe_2O_3 are being used,

Table 2. Canada, chromium trade and consumption, 1963-72[1]

	Imports		Exports	Consumption[2]	
	Chromite[1]	Ferro-chromium[2]	Ferro-chromium[2]	Chromite	Ferro-chromium
1963	49,654		2,910	56,016	9,662
1964	20,794	10,482	172	57,734	11,212
1965	35,408	15,336	205	69,105	12,903
1966	20,880	12,536	35	64,550	17,200
1967	34,485	21,740	--	70,549	19,557
1968	22,401	15,045	1	77,075	45,696
1969	41,924	25,123	. .	68,484	25,035
1970	30,445	22,943	. .	61,963	31,257
1971	32,716	39,906	. .	61,313	22,861
1972[p]	24,728	15,204	. .	. .	. .

Source: Statistics Canada.

[1]To 1963, gross weight; from 1964, chromium content. [2]Gross weight.
[p]Preliminary; . . Not available; –Nil.

Table 3. Consumption of chromite and tenor of ore used by primary consumer groups in the United States, 1964-71

	Metallurgical Industry		Refractory Industry		Chemical Industry		Total	
	Gross Weight	Average Cr_2O_3	Gross Weight	Average Cr_2O_3	Gross Weight	Average Cr_2O_3	Gross Weight	Average Cr_2O_3
	(thousand short tons)	(%)	(thousand short tons)	(%)	(thousand short tons)	(%)	(thousand short tons)	(%)
1964	832	49.0	430	33.8	189	45.1	1,451	44.0
1965	907	49.8	460	34.7	217	45.0	1,584	44.8
1966	828	49.6	439	34.6	194	44.9	1,461	44.5
1967	866	49.7	310	34.0	179	45.2	1,355	45.5
1968	804	49.7	311	34.1	202	45.1	1,316	45.4
1969	898	49.1	302	35.0	211	45.1	1,411	45.5
1970	912	48.0	278	35.9	213	45.3	1,403	45.2
1971	720	47.8	193	36.3	180	45.6	1,093	45.4

Source: Preprint from 1971 U.S. Bureau of Mines *Minerals Yearbook*.

principally in South Africa, to supply prepared chromite sands to the metallurgical industry for use in foundry moulds.

The chemical industry uses chromite that averages about 45 per cent Cr_2O_3; the chrome-to-iron ratio is usually about 1.6 to 1. Friable ores and fines are acceptable but Cr_2O_3 content should not be less than 44 per cent, alumina (Al_2O_3) not more than 15 per cent, and not over 20 per cent total iron and 5 per cent silica.

Uses

Chromium is used in three principal industrial activities: the metallurgical, chiefly in the form of ferrochromium for addition to steel; the refractory, in making chemically neutral refractory bricks and furnace linings; and the chemical.

Metallurgical uses account for about 65 per cent of world consumption with intermediate consumption in the form of several ferroalloys. More than 65 per cent of chromium in ferroalloy consumption is used for the production of stainless and heat-resistant steels. Other uses include specialty steels, and grey and malleable iron. Typical stainless and heat-resistant steels contain from 11.5 to 26 per cent chromium; grey and malleable iron contain up to 2 per cent chromium. Chromium is used in a variety of other alloy steels ranging in content from less than one per cent to as much as 35 per cent chromium.

As a steel alloying element chromium imparts desirable properties such as resistance to oxidation and corrosion and ability to withstand stress at high temperatures. In cast iron, chromium refines the grain structure and increases strength and wear resistance. Nickel-chromium alloys have an outstanding degree of resistance to oxidation and their use as electrical heating elements is well established.

Table 4. World production of chromium ore, 1970-72

	1970	1971	1972[e]
	(thousands of short tons)		
U.S.S.R.[e]	1,930	1,980	2,100
Republic of South Africa	1,573	1,812	2,000
Philippines	624	476	400
Turkey	759	665	650
Rhodesia[e]	400	400	400
Albania	516	590[e]	
India	299	288	
Iran[e]	220	220	
Finland	162	153	
Malagasy Republic	144	154	
Yugoslavia	45	38	
Greece	29	27	1,600[1] (Albania to Brazil)
Japan	36	35	
Pakistan	32	27	
Cyprus	37	45	
Sudan	52	23	
Brazil	30	37[e]	
Total	6,888	6,970	7,150

Sources: U.S. Bureau of Mines Preprint for 1971; Commodity Data Summary, January 1973 for 1972.
[1] Author's estimate.
[e] Estimated.

The second largest use of chromium is in refractories, which account for some 22 per cent of world consumption. Chromite finds applications in refractories because of its high melting point, moderate thermal expansion and its resistant, chemically neutral nature. Chromite usage in the refractory industry is

Table 5. Composition of typical grades of ferrochromium and chromium metal[1]

Grade	Chromium	Silicon	Carbon
	(per cent of principal constituents)		
Ferrochromium			
High-carbon			
standard grade	66-77	1-2	4-6
charge grade	50-70	2-7	6-8
blocking and foundry grade	55-63	8-12	4-5
Medium-carbon	60-65	3 max	2.5-3
Low-carbon	65 min	1.5 max	0.1-0.6 max
Ferrochromium-silicon, 34/46 grade	33-36	45-48	0.05 max
Chromium metal			
Electrolytic	99.8 min		
High-carbon	87-90		9-11
Low-carbon	97		0.1-0.5 max

[1] Difference between sum of percentages shown and 100 chiefly iron.

declining because the quantity of steel produced in open-hearth furnaces, the principal consumer of chromite refractories, is declining. Many open-hearth furnaces have been replaced by basic oxygen furnaces (BOF) during the past 10-15 years and nearly all will be replaced by 1980 because BOF's operate more rapidly and economically. In addition, the magchrome (magnesite-chromite) brick in which magnesite is the predominant constituent is being used more, in preference to the chrome-mag brick in which chromite is the predominant constituent. Use of the pure chromite brick has also declined and presently it forms a small part of total consumption.

Chromium chemicals account for an estimated 13 per cent of world chromite consumption. The principal chemical uses for chromium compounds are in electroplating of metals, tanning and treatment of textiles, chemical conversion coatings for decorative and anticorrosion effects, pigments, dyes, wood preservatives and fungicides. The primary chemicals produced from chromite are chromates and dichromates of sodium; nearly all other chromium chemicals are derived from them.

Prices

Published U.S. prices of chromite in 1972, a long ton, fob cars Atlantic ports, were as follows: South African (Transvaal), 44 per cent Cr_2O_3, no ratio, $24-$27; Turkish, 48 per cent Cr_2O_3, 3 to 1 chromium-to-iron ratio, $55-$56; and Russia, 48 per cent Cr_2O_3, 4 to 1 ratio, $45-$46.50 (quoted per metric ton, fob Russian ports) compared with the 1971 Russian published price of $55-$56 on the same pricing basis. In July, Union Carbide Corporation, New York, and other producers reduced prices of charge chrome and high-carbon ferrochromium by 3¢ to 20¢ a pound and 23.7¢ a pound of chromium, respectively. In October, the company, together with other producers, withdrew published prices for low-carbon, charge chrome and ferrochrome silicon in the wake of severe competition from imported alloys and discounted U.S. prices.

Chrome prices published by *Metals Week*

	December 20 1971	December 22 1972
	(U.S. $)	(U.S. $)
Chrome ore per long ton, dry basis, subject to penalties if guarantees not met, fob cars Atlantic ports		
Transvaal 44% Cr_2O_3, no ratio	25-27	24-27
Turkish 48% Cr_2O_3, 3:1 ratio	55-56	55-56
Russian 54-56% Cr_2O_3, 4:1 ratio, per metric ton in 1971	51.50-55.00	45.00-46.50
Chromium metal		
Electrolytic, 99.8%, fob shipping point, per lb	1.30	1.30
Vacuum melting (pellet) per lb	1.37	1.37
9 per cent C, per lb	1.56	1.56
Aluminothermic, delivered per lb, 99.25%	1.15	1.30
Ferrochrome per lb Cr content, fob shipping point	(¢)	(¢)
High-carbon 67-70% Cr, 5-6% C	26.7	23.7
Charge chrome, 63-71% Cr, 3% Si max, 0.04% S, 4.5-6% C	23.0	–
Imported charge chrome	21.0[n]	19.0-19.5
Blocking chrome		
10-14% Si	27.6	27.6
14-17% Si	28.6	28.6
Chromsol, 57-62% Cr, 4-6% Mn, 1.5% Si, 6.5%, per lb, alloy, fob shipping point	15.55	14.65
HS chrome – 66	42.5	42.5
Low-carbon		
67-73% Cr, 0.025% C	39.5	–
67-71% Cr, 0.05% C	38.0	–
Simplex, 0.01% max C	39.5	–
Simplex, 0.020% max C	38.0	–

Chrome prices (concl'd)

	December 20 1971		December 22 1972	
Ferrochrome (cont)	(U.S. $)		(U.S. $)	
Imported low-carbon				
delivered 0.05% C	35.75-36.0[n]		–	
0.025% C	37.0-37.5[n]			
	Cr	Si	Cr	Si
	(¢)	(¢)	(¢)	(¢)
Ferrochrome silicon, per lb Cr plus lb Si				
36/40, 0.05% C	26.25	16.0	–	–
40/43, 0.05% C	29.0	16.0	–	–
"L", 0.02% C	30.0	16.0	–	–

[n]Nominal; – No quote.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
32900-1	Chrome ore	free	free	free
35700-1	Chromium metal, in lumps, powder, ingots, blocks, or bars and scrap alloy metal containing chromium for use in alloying purposes	free	free	free
37506-1	Ferrochrome	free	5	5
92821-1	Chromium oxides and hydroxides, from July 15, 1971 to Jan. 31, 1973 with the exception of the following:	free		
	Chromic oxides	10	15	25
	Chromium trioxide	10	15	25
92838-8	Chromium potassium sulphate	free	free	10
92828-9	Chromium sulphate, basic	free	free	10

United States

Item No.			On and After January 1 1971	1972
601.15	Chrome ore	free		
			(%)	(%)
632.18	Chromium metals, unwrought (duty on waste and scrap suspended)		6	5
633.00	Chromium metal, wrought		10.5	9
632.84	Chromium alloys, unwrought			
	Ferrochromium		10.5	9

Tariffs (concl'd)

United States (concl'd)

		On and After January 1	
		1971	1972
607.30	Not containing over 3% by weight of carbon	5	4
607.31	Containing over 3% by weight of carbon	0.625¢ per lb on chromium content	
416.45	Chromic acid	7	6
422.92	Chromium carbide	7	6
531.21	Chrome brick	15	12.5
473.10	Chrome colours	6	5
420.98	Chromate and dichromate	1.05¢ per lb	0.87¢ per lb

Sources: For Canada the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1972), TC Publication 452.

Clays and Clay Products

G.O. VAGT

Clays are secondary minerals, hydrous aluminum silicates, formed by the chemical weathering or alteration of aluminous minerals such as feldspar and mica. They are classified into three major groups based on detailed chemistry and structure: the kaolinite group, the montmorillonite group and the illite group. Clay deposits suitable for the manufacture of ceramic products may include nonclay minerals such as quartz, calcite, dolomite, feldspar, gypsum, mica, iron-bearing minerals and organic matter. The nonclay minerals may, or may not be deleterious, depending upon individual amounts present.

The commercial value of clays and shales that are similar in composition to clays, depends mainly on their physical properties and location. Properties of prime importance are: plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption.

Canadian industry and developments

In 1972 the value of products manufactured from Canadian clays was $49.0 million, compared with $48.6 million in 1971. The increase was largely a result of expansion in the residential construction industry, which reached a record level in 1972. One hundred and sixty-nine active companies operated 194 plants classified within the ceramics industry in 1972, based on final data compiled in *Operators List* 6, Ceramic Plants in Canada, published by the Mineral Resources Branch.

The Atlantic provinces. Four brick and tile manufacturing plants are operated in the Atlantic provinces. The L.E. Shaw, Limited plant at Lantz, Nova Scotia will undergo alterations of three round kilns and one tunnel kiln, in addition to improving the material preparation process. The modernization will effect a 15-20 per cent increase in production capacity. Local raw materials include shale, stoneware clays, red clay and fireclay.

A plant operated by E. and A. Lorenzen at Lantz, Nova Scotia produced art pottery and stoneware utilizing local sources of red and buff clay. Ahlstrom Canada Limited of Moncton, New Brunswick manufactured glass containers from imported silica sand and domestic nepheline syenite. Two porcelain enamel plants in New Brunswick, each with a total capacity of over one hundred thousand square feet per month, utilized local sources of commercial frit for the spray and dip processes on cast iron and sheet steel.

Quebec. Eight major brick and tile plants operated in Quebec producing products from local shale and clay. No production of sewer pipe was reported. Thirteen plants classified as porcelain and pottery plants, including five which manufactured art pottery, were operated. Chinaware, electrical porcelain, wall and floor tiles, vitreous sanitary ware and ferrite products were also produced. The principal consumers of ceramic-grade china clay and ball clays imported their entire requirements from the United States or England. Refractory products were produced by five plants which manufactured products such as bricks, mortars or ramming mixes. Most raw materials, including ball clay, fire clay and flint clay, were imported. Two abrasive plants manufactured crude silicon carbide and one manufactured resin bond sanding disks. Domestic raw materials included silica sand, fused alumina and resins. Petroleum coke was imported. Four glass plants were operated using mainly domestic raw materials. Five porcelain enamel plants situated in Montreal used domestic commercial frit primarily in spray and dip processes on cast iron and sheet steel.

Ontario. Thirty-nine major brick and tile plants operated in Ontario. Most of these are situated in the Toronto-Hamilton area and in the extreme southwestern part of the province. Local resources of common clay or shale were utilized, primarily in the stiff-mud process for the manufacture of brick and tile products. Two companies manufactured sewer pipe and flue lining by the stiff-mud process from imported fire clay and local raw materials. Products classified as porcelain and pottery were manufactured by twenty-nine plants, nine of which make art pottery. The remainder mainly produced sanitary ware products, electrical porcelain, wall and floor tile, dinnerware products and ferrites. Nepheline syenite, common clay and feldspar were acquired locally. Ball clay, china clay, talc and flint were imported. Thirteen plants manufactured refractory products from imported ball clay, fireclay, refractory grogs and flint clays. Bonded abrasives were manufactured at six plants using about 50 per cent domestic raw materials. All silicon carbide utilized was obtained in Canada. The principal product of the seven glass plants operating in Ontario was glass containers. One plant produced glass fibre insulating products from imported silica sand and domestic nepheline syenite, limestone, soda ash and dolomite. Eighteen porcelain enamel plants were operated.

The Prairie Provinces. In Manitoba local stoneware clay was used to manufacture face brick by the stiff-mud and dry-press processes. In Saskatchewan brick and sewer pipe were manufactured at one plant and common and face brick at another. The former plant, in Regina, and the latter, in Estevan, have reported capacities of 1,500 tons per month and 1.5 million bricks per month. In Alberta, plants in Edmonton, Medicine Hat and Redcliff manufacture brick and tile. In southern Alberta six porcelain and pottery plants manufactured products including stoneware, sanitary ware, electrical porcelain and dinnerware. Local common clay and fireclay, and imported ball clay and china clay were used. Only one refractory plant operated in the region in 1972, producing fireclay refractories, special shapes and face brick from local and imported sources of fireclay. Four glass plants, all in Alberta, produced varied products including containers, glass wool, glass fibre mats, pipe covering and plastic pipe, primarily from domestic raw materials.

British Columbia. Brick or tile products were manufactured at three plants and sewer pipe at one plant in B.C. These are situated in Vancouver, Haney and Kilgard. One plant, in Coquitlam, manufactured vitreous sanitary ware and three plants, in Haney, Sardis

Table 1. Canada, production of clay and clay products from domestic sources, 1970-72

	1970^r	1971	1972^p
	($000)	($000)	($000)
Production[1] from domestic sources, by provinces			
Newfoundland	37	79	80
Nova Scotia	2,816	1,758	1,649
New Brunswick	940	627	656
Quebec	8,160	6,119	8,075
Ontario	28,649	29,815	28,907
Manitoba	346	322	374
Saskatchewan	1,819	998	1,409
Alberta	4,657	3,833	4,507
British Columbia	4,367	5,032	3,341
Total, Canada	51,791	48,583	48,998
Production[1] from domestic sources, by products			
Clay – fireclay	55	1,063	70
other clay	866		1,154
Firebrick and fireclay blocks and shapes	1,289	1,655	1,719
Brick – soft mud process	1,452	1,849	
stiff mud process	29,266	25,122	35,722
dry press, mainly face brick	3,586	4,048	
fancy or ornamental	875	651	
sewer brick and paving brick	184	71	
Structural hollow blocks	659	839	248
Drain tile	6,748	5,224	2,949
Sewer pipe	3,677	4,306	4,877
Flue linings	1,125	1,207	
Pottery (glazed and unglazed), including earthenware, sanitary ware, stoneware, flower pots, etc.	2,009	2,548	2,259
Total	51,791	48,583	48,998

Source: Statistics Canada.
[1] Producers' shipments. Distribution for 1972 estimated by Statistics Section, Mineral Resources Branch.
^{p}Preliminary; ^{r}Revised.

and Saanichton, manufactured pottery. Refractories were produced at three plants that are situated in Abbotsford, Surrey and Vancouver. Glass containers were manufactured by one company in Burnaby and one in Lavington.

Summary. The brick and tile manufacturing industry accounts for approximately one third of the ceramic plants in Canada. These plants manufacture clay products which include common brick, facing brick, structural tile, quarry tile and drain tile, primarily from local common clays and shales. In recent years requirements for brick as a structural material in low- to medium-rise buildings have been emphasized. The use of an oversize 'through the wall' (TTW) brick, which provides wall thickness, now provides a significant market for brick manufacturers.

Seven plants manufacture sewer pipe from domestic common clay, shale or stoneware clay along with some imported shale and fireclay. Of the porcelain and

Table 2. Canada, imports and exports of clay, clay products and refractories

	1971		1972^p	
	(short tons)	($000)	(short tons)	($000)
Imports				
Clays				
Bentonite	346,800	3,295	306,227	3,346
Drilling mud	4,542	1,500	14,098	2,671
China clay, ground or unground	202,440	5,718	232,036	6,324
Fireclay, ground or unground	67,706	1,093	49,348	901
Clays, ground or unground	61,833	654	76,184	939
Clays and earth, activated	12,699	1,757	36,632	2,381
Subtotal, clays	696,020	14,017	714,525	16,562
Clay products				
Brick-building	(M)		(M)	
glazed	1,361	115	2,153	186
nes	16,995	1,233	22,639	1,605
Building blocks	..	210	..	197
Clay bricks, blocks and tiles, nes	..	102	..	285
Earthenware tile	(ft^2)		(ft^2)	
under 2½ x 2½"	12,631,192	2,606	19,681,017	4,678
over 2½ x 2½"	18,103,836	3,704	31,323,111	6,700
Subtotal, bricks, blocks, tiles	..	7,970	..	13,651
Tableware, ceramic	..	27,577	..	33,231
Porcelain insulating fitting	..	5,275	..	5,760
Pottery settings and firing supplies	..	188	..	248
Subtotal, porcelain, pottery	..	33,040	..	39,239
Refractories				
Firebrick	(st)		(st)	
Alumina	25,964	4,553	27,160	5,464
Chrome	6,911	1,009	2,841	437
Magnesite	5,964	1,844	11,506	3,103
Silica	18,007	3,351	5,638	1,203
Nes	174,556	13,090	180,407	13,334
Refractory cements and mortars	..	2,612	..	2,561
Acid-proof brick	..	307	..	202
Crude refractory material	8,287	688	7,464	608
Grog (refractory scrap)	17,919	594	15,795	616
Refractories, nes	..	1,437	..	1,472
Subtotal, refractories	..	29,485	..	29,000
Total clay, clay products and refractories	..	84,512	..	98,452

Table 2 (concl'd)

	1971		1972^p	
	(short tons)	($000)	(short tons)	($000)
Imports (cont'd)				
By main countries				
United States		42,764		47,702
Britain		21,191		25,051
Japan		10,318		14,668
West Germany		4,539		2,862
Italy		1,072		2,403
France		650		695
Austria		310		579
Ireland		825		480
Greece		606		242
Belgium and Luxembourg		283		90
Other countries		1,954		3,680
Total		84,512		98,452
Exports				
Clays, ground and unground	4,386	103	4,685	227
Clay products	(M)		(M)	
Building brick clay	9,511	995	17,098	1,392
Clay bricks, block, tiles, nes	..	611	..	628
Subtotal, brick, blocks, tiles	..	1,606	..	2,020
High-tension insulators and fittings	..	1,031	..	971
Tableware	..	3,259	..	3,179
Subtotal, porcelain, tableware	..	4,290	..	4,150
Refractories	(st)		(st)	
Firebrick and similar shapes	57,132	7,970	46,721	7,144
Crude refractory materials	765,102	760	973,113	861
Refractories, nes	..	846	..	1,547
Subtotal refractories	..	9,576	..	9,552
Total clays, clay products and refractories	..	15,575	..	15,949
By main countries				
United States		9,603		11,487
South Africa		412		584
Britain		787		457
Dominican Republic		318		435
Jamaica		170		223
Australia		156		181
France		267		173
Italy		122		160
Greece		219		152
Puerto Rico		255		143
Senegal		51		123
Ireland		230		104
Colombia		90		103
Other countries		2,895		1,624
Total		15,575		15,949

Source: Statistics Canada.
^p Preliminary; .. Not available; nes Not elsewhere specified; M = 1,000.

Table 3. Canada, shipments of clay products produced from imported clay[1] 1969-71

	1969^r		1970		1971	
	('000 ft^2)	($000)	('000 ft^2)	($000)	('000 ft^2)	($000)
Glazed floor and wall tile	15,271	6,406	13,228	5,622	15,023	5,820
Electrical porcelains	..	12,050	..	15,837	..	18,592
Pottery, art and decorative ware	..	2,133	..	1,643	..	1,576
Pottery, other	..	1,767	..	1,725	..	..

Source: Statistics Canada.
[1]Does not include refractories.
^{r}Revised; . . Not available.

pottery producers, seven sanitary ware plants, eight electrical porcelain plants, five wall tile plants (including two that also make floor tile), four dinnerware plants and the art potteries are the principal consumers of ceramic-grade china clay and ball clays. These raw materials are imported mainly from the United States and Britain. Some of the art potteries and one of the dinnerware plants imported unfinished ware and completed the manufacturing process by glazing or decorating.

Most of the 22 plants that manufactured refractories utilized imported clay including ball clay, fireclay and kaolin, as the principal ingredients in many of their products. Only the British Columbia producers of refractories were able to operate with domestic raw materials by making use of the clay at Sumas Mountain. The nine abrasives plants utilized both domestic and imported raw materials. The distribution was approximately half and half, except for silicon carbide, which was supplied entirely from domestic sources, and petroleum coke, which was imported. The eighteen glass plants mainly utilized domestic sources of raw materials, except those in Quebec and Ontario, which accounted for most of the imported silica sand used. Porcelain enamel was produced and utilized at 25 plants.

Uses, nature and location of deposits

Common clay and shale. Common clays and shales are the principal raw materials available from Canadian deposits for the manufacture of clay products. These materials are usually higher in alkalis, alkaline materials and iron-bearing minerals and much lower in alumina than the high-quality kaolins, fireclays, ball clays and stoneware clays. Common clays and shales are found in all parts of Canada, but deposits having excellent drying and firing properties are generally scarce and new deposits are continually being sought.

The clay minerals in common clays and shales are chiefly illitic or chloritic. The presence of iron usually results in a salmon or red fired colour. Their fusion points are low, usually well below pyrometric cone equivalent number 15 (PCE 15–the pyrometric cones are a convenient method of relating temperature and time by a single value), which is defined by a temperature of approximately 1430°C and is considered to be the lower limit of the softening point for fireclays.

Suitable common clays and shales are utilized in the manufacture of heavy clay products such as common brick, facing brick, structural tile, partition tile, conduit tile, quarry tile and drain tile. Some Canadian common clays are mixed with stoneware

Table 4. Canada, shipments of refractories, 1969-71

	1969^r		1970		1971^p	
	(st)	($000)	(st)	($000)	(st)	($000)
Firebrick and similar shapes[1]	116,518	17,636	139,384	22,236	145,504	21,875
Cements, mortars, castables	83,158	12,715	96,754	13,778	95,196	13,909

Source: Statistics Canada.
[1]Includes fireclay blocks and shapes, firebrick, etc., made from domestic clays, and rigid firebrick, stove linings and other shapes made from imported clays, chrome ore, magnesite, etc. Silica brick not included.
^{r}Revised; ^{p}Preliminary.

Table 5. Canada, clay and clay products production and trade, 1963-72

	Production					
	Domestic clays[1]	Imported Clays[2]	Total	Refractory Shipments[3]	Imports[4]	Exports[4]
				(millions of dollars)		
1963	38.2	25.2	63.4	21.0	43.9	7.6
1964	40.8	30.2	71.0	25.3	54.7	8.9
1965	42.8	31.4	74.2	27.4[r]	59.4	10.3
1966	43.0	35.9[r]	78.9[r]	28.6[r]	71.7	12.6
1967	44.3	35.5[r]	79.8[r]	30.7[r]	70.7	13.7
1968	48.7	39.6[r]	88.3[r]	33.2[r]	65.4	11.8
1969	49.5[r]	34.5[r]	84.0[r]	35.5[r]	76.3	14.0
1970	51.8[r]	33.6[r]	85.4[r]	42.3[r]	81.2	15.6
1971	48.6	35.1	83.7	39.8	84.5	15.5
1972[p]	49.0	..	..	..	98.5	15.9

Source: Statistics Canada.
[1]Production (shipments) of clay and clay products from domestic material. [2]Production (shipments) of clay products from imported clays. [3]Includes firebrick and similar shapes, all types, refractory cements, mortars, castables, plastics, etc., plus all other products shipped. [4]Includes refractories.
[p]Preliminary; .. Not available; [r]Revised.

clay for the manufacture of facing brick, sewer pipe, flue lining and related products. The raw materials utilized in the heavy clay industry usually contain up to 35 per cent quartz. If the quartz, together with other nonplastic materials, exceeds this percentage, the plasticity of the clay is reduced and the quality of the ware is lowered. If calcite or dolomite is present in sufficient quantities the clay will fire buff and the fired strength and density will be adversely affected.

Most of the common surface clays are the result of severe glaciation. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and nonmarine sediments, reworked glacial till, interglacial clays and floodplain clays. These deposits are characterized by low melting temperatures. Some Tertiary and Cretaceous deposits that occur near the surface are of interest. An important characteristic of these older deposits is the wide range of refractoriness, or fusibility, depending on the locality and the nature of the formation.

The common shales have been found to provide the best source of raw material for making brick. The principal shales useful to the ceramic industry are found in Cambrian, Ordovician and Carboniferous rocks in eastern Canada, and Jurassic, Cretaceous and Tertiary rocks in western Canada. In many instances these shales are more refractory than the Pleistocene clays; in some areas, particularly in western Canada, they are very refractory.

China clay (kaolin). China clay is a high-quality white, or nearly white, clay formed from the decomposition of the mineral feldspar, a major constituent of granite. The natural decompositional process, known as kaolinization, results in a hydrated aluminum silicate ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) with the approximate percentage composition as follows: 40% Al_2O_3, 46% SiO_2 and 14% H_2O.

None of the crude kaolins known to exist in Canada have been developed, primarily because of beneficiation problems and the small size of some deposits. Most occurrences contain a high proportion of quartz with particles that vary from coarse to very fine. High proportions of substances such as mica, feldspar, magnetite, pyrite and colloidal iron have been observed. In the crude material the percentage of kaolinite frequently is small, making removal of impurities from Canadian kaolins difficult.

China clay is used primarily as a filler and coater in the paper industry, a raw material in ceramic products and a filler in rubber and other products. The following properties are required in clays used by the paper industry: low viscosity characteristics when in clay-water systems, intense whiteness, high coating retention and freedom from abrasive grit. In the ceramic industry china clay is used as a refractory raw material. In prepared whiteware bodies such as wall tile, floor tile, sanitary ware, dinnerware, pottery and electrical porcelain, quantities of nepheline syenite, silica, feldspar and talc are used as well.

Lower-quality kaolins in North America may be mined and more expensive processing may be justified as higher-quality kaolins become depleted. If this situation arises, the development of a few Canadian deposits may become more attractive, particularly if new processing techniques and equipment become available.

In southern Saskatchewan deposits of sandy kaolin occur near Wood Mountain, Fir Mountain, Knollys, Flintoft and other localities. Despite considerable work, no satisfactory method of producing a good commercial kaolin from these deposits has been developed.

A deposit of refractory clay which is very plastic to very sandy, and is similar to a secondary china clay, occurs along the Fraser River near Prince George, British Columbia. This material has been investigated as a source of kaolin, as a fireclay and as a raw material for facing brick.

Various kaolinitic-rock deposits have been investigated in Manitoba. The reported deposits are principally in the northwest at Cross Lake and Pine River, on Deer Island (Punk Island) and Black Island in Lake Winnipeg, and at Arborg. Kaolinitic clays occur near Kergwenan and are being used for the manufacture of brick and tile.

Various companies have shown considerable interest in Quebec's kaolin-bearing deposits although the deposits, in general, contain an excessive amount of quartz and iron minerals. Kaolin-bearing rock occurs at St-Rémi-d'Amherst, Papineau County; Brebeuf, Terrebonne County; Point Comfort, on Thirtyone Mile Lake, Gatineau County, and Château-Richer, Montmorency County.

Extensive deposits of kaolin-sand mixtures occur in northern Ontario along the Missinaibi and Mattagami rivers. Algocen Mines Limited has found substantial quantities of kaolin-silica mixtures along the Missinaibi River north of Hearst. Results to date indicate that the kaolin has good refractory characteristics and meets specifications for filler-grade material. Potential uses for the silica, which comprises 80 per cent of the deposit, include glass manufacture, abrasive flour and ceramic applications. Distance from markets and the difficult terrain and climate of the area have hindered development.

Ball clay. Ball clays are a very fine grained, sedimentary kaolinitic type of clay with unfired colours ranging from white or various shades of grey depending on the amount of carbonaceous material present.

Ball clays obtained in Canada are mineralogically similar to high-grade, plastic fireclay. They are composed principally of fine-particle kaolinite and quartz, with less alumina and more silica than kaolins. Ball clays are extremely refractory products. In whitewares they impart a high green strength as well as plasticity to the bodies. Although white firing clays are most suitable, fired products which are cream-coloured do not interfere with the quality of the whiteware products.

Ball clays are known to occur in the Whitemud Formation of southern Saskatchewan. Good-quality deposits are present at Willows, Readlyn, Big Muddy Valley, Blue Hills, Willow Bunch, Flintoft and in other areas. Clay from the Willows area has been used for many years in the potteries at Medicine Hat and Vancouver; however, the lack of proper quality control, the distance from large markets and lack of reserves have been the principal disadvantages affecting the widespread use of this material. Some ball clays from the Flintoft area are being used for white-to-buff facing brick and for household pottery and crocks.

Fireclay. Fireclay contain high percentages of alumina or silica, they may be sedimentary or residual in origin, plastic or nonplastic and are composed mainly of kaolinite. The classification of fireclay may be related to the composition, physical characteristics, refractoriness, use, or association with other minerals. Descriptive terminology includes plastic fireclay, nonplastic fireclay, high-alumina fireclay, siliceous fireclay, flint clay, coal measure fireclay, or high-heat duty fireclay. Fireclays are plastic when pulverized and wetted, rigid when subsequently dried and of sufficient purity and refractoriness for use in commercial refractory products.

Canadian fireclays are used principally for the manufacture of medium- and high-duty firebrick and refractory specialties. High-duty refractories require raw materials having a PCE of about 31.5 to 32.5 (approximately 1699° to 1724°C). Intermediate-duty refractories require raw materials having a PCE of about 29 (approximately 1659°C) or higher. Clays having a PCE of less than 29 but greater than 15 (approximately 1430°C) may be suitable for low-duty refractories or ladle brick as well as for other clay products. No known Canadian fireclays are sufficiently refractory for the manufacture of superduty refractories without the addition of some very refractory material such as alumina. However, in 1967 a sample from northern Ontario having a PCE of 33 was examined at the Mines Branch of the Department of Energy, Mines and Resources, Ottawa.

Various grades of good-quality fireclay occur in the Whitemud Formation in southern Saskatchewan.

Good-quality fireclays occur on Sumas Mountain in British Columbia. Some fireclay from the Sumas deposit is exported to the United States, and a small quantity is used at plants in Vancouver.

Fireclay and kaolin, as previously stated, occur in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. Considerable exploration has been carried out in some parts of these areas in recent years.

At Shubenacadie, Nova Scotia, some seams of clay are sufficiently refractory for medium-duty refractories. Research has indicated that these deposits may be suitable for production of ladle brick. Clay from Musquodoboit, Nova Scotia has been used by a few foundries in the Atlantic provinces and the properties and extent of this clay were investigated by the Nova

Table 6. Canada, consumption (available data) of china clay by industries, 1970-71

	1970	1971
	(short tons)	
Ceramic products	12,050	13,020
Paint and varnish	2,811	4,208
Paper and paper products	141,288	133,708
Rubber and linoleum	8,354	10,048
Other products[1]	16,092	9,675
Total	180,595	170,659

Sources: Statistics Canada. Component breakdown by Statistics Section, Mineral Resources Branch.
[1]Includes miscellaneous chemicals, cleansers, detergents, soaps, medicinals and pharmaceuticals and other miscellaneous products.

Scotia Department of Mines.

Ontario and Quebec have no producing domestic sources of clay. These provinces import most of their requirements from the United States.

Stoneware clay. Stoneware clays are similar to low-grade plastic clays and are characterized by good plasticity, a vitrification range between PCE 4 and 10, a long firing range and a fired colour from buff to grey. They range from commercially inferior material through semirefractory to firebrick clays. They should have low fire shrinkage, enough plasticity and toughness for shaping, no lime- or iron-bearing concretions and very little coarse sand.

Stoneware clays are used extensively in the manufacture of sewer pipe, flue liners, facing brick, pottery, stoneware crocks and jugs, and chemical stoneware.

The principal source of stoneware clay in Canada is the Whitemud Formation of southern Saskatchewan and southeastern Alberta. The Eastend area in Saskatchewan was formerly the source of much of the clay used at Medicine Hat. Stoneware clay pits are presently located in the Alberta Cypress Hills, southeast of Medicine Hat, and at Avonlea, Saskatchewan. Stoneware clays occur on Sumas Mountain, near Abbotsford, British Columbia. These clays are used in the manufacture of sewer pipe, flue lining, facing brick and tile.

In Nova Scotia stoneware clays occur at Shubenacadie and Musquodoboit. The Shubenacadie clays are used principally for the manufacture of buff facing brick. Other similar deposits occur at Swan River, Manitoba, where some buff brick has been manufactured, Kergwenan, Manitoba and in British Columbia at Chimney Creek Bridge, Williams Lake, Quesnel and near the Alaska Highway at Coal River.

Quebec and Ontario import stoneware clay from the United States for manufacture of facing brick and sewer pipe.

Specifications and uses

The following specifications, published by the Canadian Standards Association, are applicable to the specified clay products manufactured in Canada:

A 82.1 – 1965 Burned clay brick
A 82.2 – 1967 Methods of sampling and testing brick
A 82.3 – 1954 Sand-lime building brick
A 60.1 – 1969 Vitrified clay pipe
A 60.2 – 1962 Methods of testing vitrified clay pipe
A 60.3 – 1969 Vitrified clay pipe joints
A 82.5 – 1954 Structural clay non-load-bearing tile (reaffirmed 1967)
A 82.6 – 1954 Standard methods for sampling and testing structural clay-tile (reaffirmed 1954 and 1967)

Expanded common clays and shales are utilized as thermally expanded lightweight aggregates and are reviewed separately in "Lightweight Aggregates".*

*See No. 1 in this series of mineral preprints.

Table 7. Ceramic Plants in Canada, 1971

Type of Plant	Atlantic	Quebec	Ontario	Prairie Provinces	British Columbia	Total
Brick and tile	4	8	39	6	3	60
Clay sewer pipe	2	–	2	2	1	7
Porcelain and pottery	1	13	29	6	4	53
Refractories	–	5	13	1	3	22
Glass	1	4	7	4	2	18
Abrasives	–	3	6	–	–	9
Porcelain enamel	2	5	18	–	–	25

Note: Some plants produce more than one group of products.
Source: Based on revised data available to National Mineral Inventory, Mineral Resources Branch.
– Nil.

World review

United States. Total mine production of clays, including bentonite and fuller's earth, was an estimated 59,965,000 short tons in 1972. This was about 5 per cent above the total for 1971.

The major uses for clays, other than those used in the heavy clay products industry, were as follows: refractories, paper manufacture, iron ore pelletizing, absorbent and filtering uses, and pottery and stoneware.

The United States export market for quality kaolin has generally increased in recent years, primarily from the fast rate of industrial growth in several European countries. Production of kaolin increased over that of 1971 but did not reach the production capacity of the industry. Exports to Europe and Asia remained essentially the same as in 1971.

Britain. Britain is the world's leading producer of kaolin and ball clay for export. Approximately 20 per cent of total clay production is exported, according to sources available to the United States Bureau of Mines. Major growth areas for British exports have been Europe, the United States and Japan. In western Europe the major users were West Germany, France and the Netherlands, which reflects their high per capita rate of paper consumption.

Europe and Japan. The kaolin operations in continental Europe and Japan are reported to be mainly small-scale, using limited processing equipment and producing products of lower grade because of the lack of high-grade kaolin deposits. The industry in these countries is fragmented except in Bavaria (West Germany), Brittany (France) and Czechoslovakia, where significant advances are being made. Present kaolin consumption in Europe and Japan is largely in paper manufacture; however, local producers have so far had only limited success in the market because quality is inadequate. West Germany, with a production of nearly 500,000 tons, is the second largest producer of kaolin in Europe. Most of the kaolin is used in the ceramic and other industries to which it is best suited.

Czechoslovakia is the largest producer of kaolin in eastern Europe. Output is reported to be approximately 400,000 tons a year. The high quality of the kaolin is indicated by the fact that about 180,000 tons is consumed in paper manufacture. Czechoslovakia is increasing its share of the European market at the expense of British and U.S. kaolin. In France many companies produce kaolin, although operations are generally small, fairly widely dispersed and relatively distant from major markets. On the other hand, the industry in Brittany, which accounts for about 80 per cent of France's output, is expected to expand its production substantially through more integrated support by a central body in Paris. Also, a major American producer has acquired an interest in an operation in Brittany, which will bring new capital to the region along with additional technical and marketing expertise.

Spain has the fourth largest production of kaolin in western Europe. In 1970 the estimated total was 285,000 tons. Output was reported to have expanded over two and a half times since 1960 and, according to the National Mining Plan, which envisages a complete modernization of many of the operations, output will double again by 1976.

Greece produces approximately 60,000 tons of kaolin annually, almost all for domestic consumption.

Denmark produces between 30,000 and 35,000 tons of kaolin a year. Most of the output is utilized in the manufacture of low-alumina refractories and glazed heavy-clay products. Requirements for paper and other uses are mainly imported from Britain, Czechoslovakia and West Germany.

The Netherlands produces no kaolin but acts as a very important distribution point for American and British clay entering Europe.

Production of kaolin in Japan is on a very small scale except at the Itaya Mine, Yamagata Prefecture, Honshu Island, which produces about 150,000 tons per year. Total kaolin output is approximately 390,000 tons a year based on USBM statistics. Most of the production goes into the manufacture of refractories, for which it is best suited. The United States is the principal source of imports, supplying about 100,000 long tons annually. Lesser amounts of kaolin are imported from South Korea, Britain and the U.S.S.R.

Outlook

The broad aspects of the clay industry in Canada have not changed appreciably for many years. Continued activity in residential, commercial and industrial building construction indicates that demand for most clay and clay products will remain high in 1973. The cyclical nature of the construction industry is a major problem because compensating adjustments in plant output must be made.

The few known deposits of fireclays and ball clays in the developed areas of Canada are being utilized. Much work has been carried out on deposits containing kaolin but these have not been developed because of small size, high cost of beneficiation, or remoteness from transportation or industry. Ontario and Quebec are particularly deficient in developed deposits of refractory- or kaolin-type clays. Lower-quality deposits in the United States and Britain, the major export countries, will be utilized in the future, probably at increased cost and as a result of the development of improved beneficiation methods.

There has been a great increase in ways that kaolin can be processed, both chemically and mechanically. This trend is continuing as producers endeavour to increase markets and to meet the tighter specifications of industries in which consumers are placing much more emphasis on brightness, colour and viscosity. In the United States continued demand for paper grades, particularly for coating, is assured, barring adequate substitutes. The rubber industry will continue to be a big consumer, but its recent steady intake suggests that it will not expand very rapidly. The ceramics market, in common with the rubber market, is already large and not expanding rapidly. Paint and fibreglass applications are good potential growth areas, if the right grades are developed; newer uses, such as for catalysts in oil-refining, may prove to be growing markets. A recent increase of up to 25 per cent in the refractories market has been noted in Canada. Proportionally, there has been a decrease in the use of fireclay brick and an upswing in materials such as high alumina, alumina silicates, basic refractories and monolithics (a family of materials applied by means of casting, ramming, or gunning to form a virtually jointless furnace lining). The major emphasis in the production of refractory products will be to cope with the higher operating temperatures and greater throughputs required in industrial furnaces; the higher-grade, superduty refractories are in heavy demand. Steel processes such as the basic oxygen furnace, pressure pouring and continuous casting, represent relatively new refractory requirements. New products and designs have also been dictated by changes in reducing atmospheres in the chemical and petrochemical industry, by increased demands for high-purity glass and by the need for more economical production of ceramics.

Clay and shale, like other low-cost construction materials, must be produced near the heavily populated areas where the markets are situated. This necessary feature of the industry will continue to produce increasingly complex problems related to rising land costs, land-use conflicts, environmental control requirements, and cost of land rehabilitation. Demands in industry have indicated that some end-use products such as brick and tile find competition from cement, glass, metals and plastic manufacturers. On the other hand, clays, being generally less expensive and very satisfactory for their intended uses, are usually able to hold their own, or to increase at the expense of the alternate materials, for many end uses.

Bentonite and fuller's earth

Bentonite, a clay which consist primarily of montmorillonite, a hydrous aluminum silicate with weakly attached cations of sodium and calcium, is reviewed separately.*

Fuller's earth is primarily a calcium montmorillonite clay characterized by natural bleaching and absorbent properties; it is similar to nonswelling bentonite. The terminology is confusing and bentonite and fuller's earth may not necessarily be separated in world trade and production statistics by country. Attapulgite, a magnesium-aluminum silicate, is a form of high-quality fuller's earth.

Prices

United States clay prices, according to Oil, Paint and Drug Reporter, December 25, 1972

	($ per ton)
Ball clay	
Domestic, crushed, moisture-repellent, bulk car lots, fob Tennessee	8 – 11.25
Imported lump, bulk, fob Great Lakes ports	40.50
Imported, airfloated bags, car lots, Atlantic ports	70
China clay (kaolin)	
Water-washed, fully calcined, bulk car lots, fob Georgia	76
Partially calcined, same basis	69
Dry-ground, air-floated soft, fob Georgia	14

* No. 6 in this series.

Tariffs

Canada Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
29500-1	Clays, including fireclay, and pipe clay not further manufactured than ground	free	free	free
29525-1	China clay	free	free	25
28100-1	Firebrick containing not less than 90% silica; magnesite firebrick or chrome firebrick; other firebrick valued at not less than $100 per 1,000, rectangular shaped, not to exceed 100 x 25 in.^{3} for use in kiln repair or other equipment of a manufacturing establishment	free	free	free

Tariffs (cont'd)

Canada (cont'd)	(%)	(%)	(%)
28105-1 Firebrick, nop, of a class or kind not made in Canada, for use in construction or repair of a furnace, kiln, etc.	free	free	15
28110-1 Firebrick, nop	5	10	22½
28200-1 Building brick and paving brick	10	10	22½
28205-1 Manufactures of clay or cement, nop	12½	12½	22½
28210-1 Saggars, hillers, bats and plate setters, when used in the manufacture of ceramic products	free	free	free
28300-1 Drain tiles, not glazed	free	17½	20
28400-1 Drain pipes, sewer pipes and earthenware fillings therefor; chimney linings or vents, chimney tops and inverted blocks, glazed or unglazed, nop	15	20	35
28405-1 Earthenware tiles, for roofing purposes	free	17½	35
28415-1 Earthenware tiles, nop	12½	20	35
28500-1 Tiles or blocks of earthenware or of stone prepared for mosaic flooring	15	20	30
28600-1 Earthenware and stoneware, viz., demijohns, churns and crocks, nop	20	20	35
28700-1 All tableware of china, porcelain, semiporcelain or white granite, excluding earthenware articles	free	20	35
28705-1 Articles of chinaware, for mounting by silverware manufacturers	12½	17½	22½
28710-1 Undecorated tableware of china, porcelain, semiporcelain for use in the manufacture of decorated tableware	free	10	35
28800-1 Stoneware and Rockingham ware and earthenware, nop	17½	20	35
28805-1 Chemical stoneware	free	10	35
28810-1 Hand forms of porcelain for manufacture of rubber gloves	free	free	35
28900-1 Baths, bathtubs, basins, closets, closet seats and covers, closet tanks, lavatories, urinals, sinks and laundry tubs of earthenware, stone, or cement, clay or other material, nop	12½	20	35

United States

Item No.	On and After January 1 1970	1971	1972
	(¢ per long ton)		
521.51 Fuller's earth, not beneficiated	35	30	25
521.41 China clay or kaolin	46	40	33
521.54 Fuller's earth, wholly or partly beneficiated	70	60	50
521.81 Other clays, not beneficiated	20	10	free
521.84 Other clays, wholly or partly beneficiated	70	60	50
521.61 Bentonite	56	48	40
521.71 Common blue clay and other ball clays not beneficiated	50	46	42
521.74 Common blue clay and other ball clays, wholly or partly beneficiated	99	92	85
521.87 Clays artificially activated with acid or other material	0.07¢lb +8.5%	0.06¢lb +7%	0.05¢lb +6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa. Tariff Schedules of the United States, Annotated (1972), T.C. Publication 452.
Note: In addition to the above tariffs various duties exist on manufactured clay products, viz., brick pottery, artware.

Coal and Coke

L.P. CHRISMAS

In 1972 Canada's expanding coal industry achieved a record level of output. Technical difficulties hampered some producers; nevertheless, gross production of all types of coal, bituminous, subbituminous and lignite amounted to 20.7 million tons valued at $150 million. Thermal coal operators continued to develop new production capability primarily to serve the expanding electric power industry. The large coking coal producers in western Canada continued to rectify unforeseen technical difficulties to reach full production capacity and to reduce operating costs. Imports of coal, all from the United States, were up slightly from the previous year to 19.3 million tons. A record 8 million tons of coking coal were exported to Japan comprising about 16 per cent of Japan's total coal imports. Coal consumption in Canada increased to an estimated 31.5 million tons in 1972, of which approximately 16.8 million tons were used to generate electric power and 7.3 million tons were carbonized to produce 5.2 million tons of coke. Smaller amounts of coal were consumed by industrial and commercial users throughout Canada.

Outlook

In reviewing the prospects for Canada's coal industry it is important to look at the two principal types of markets – coking coal and thermal coal. Virtually all of Canada's coking coal is exported and competes in the international marketplace. Largely on the basis of a greatly expanding steel industry in Japan in the 1960's, Canada was able to develop an export-oriented coking coal industry. However, in 1971 and 1972 the expansion of Japanese steel output was much reduced from the amazing rates of earlier years. Therefore, there was a restricted demand for coking coal and not the same enticement for coal resource companies to explore and prove up coking coal properties, with the result that exploration activity in 1972 was well below the previous three years. This temporary lull likely was welcome to some producers as an opportunity to improve plant technical performance. However, the long-term trend in steel output throughout the world is upwards; therefore, the coal industry can look with optimism to renewed market activity.

As far as Canada is concerned, 1972 exports of 8.3 million tons to Japan were about 70 per cent of the 12 million tons annually which Canadian companies had contracted with Japanese customers. However, considering the coking coal potential in Alberta and British Columbia, together with some output from Nova Scotia, production is estimated to reach 13 million tons by 1975 and to increase further between 1975 and 1980.

Domestically, the use of thermal coal for power generation has a promising growth potential particularly in Alberta, Saskatchewan, Ontario and in the longer term, British Columbia. Based on the utilities' plans (next five to ten years), use of coal for power generation is expected to continue to grow at an average of about 9 per cent, increasing from 17 million tons in 1972 to about 24 million tons in 1975.

In addition, there are possibilities for offshore markets. For example, in the last two years, spot shipments of steam coal have been made to several countries, including Chile, Belgium, Italy and France.

Production of all types of coal in Canada can be expected to reach 23 million tons in 1973, an increase of about 10 per cent over 1972. For 1973 it is estimated that 12.0 million tons will be exported, about 11.5 million tons going to Japan and the remainder as spot shipments to western Europe, South America and the United States. In the longer term, coal production in Canada is forecast to reach 30 million tons annually by 1975.

Production and mine developments

British Columbia. The Crowsnest Pass area has large resources of low and medium volatile bituminous coal, which have been mined since about 1898. This area is noted for its thick coal seams which occur within faulted and disturbed Lower Cretaceous rocks. Isolated smaller coal basins in other parts of the province contain coal seams ranging from lignite to anthracite. Together these regions hold promise of providing the basis for a significant coal-producing industry.

British Columbia's second and newest coking coal mine began production in April near Elkford about 40 miles north of Kaiser Resources Ltd.'s mine at Sparwood. Development of the mine by Fording Coal Limited followed the signing of an agreement in June 1969 with Japanese steel producers. During 1972 production from this mine was below planned levels because of start-up problems with the mine and preparation plant. The company expects that full production will be reached in fiscal year 1973-74. The Fording mine has a design capability of 3 million long tons of clean coal annually from two mining areas, one utilizing a shovel-truck operation and the other a

Table 1. Canada, coal production[1] by types, provinces and territories, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Bituminous				
Nova Scotia	1,965,489	23,020,853	1,425,439	16,485,324
New Brunswick	517,209	3,934,987	429,544	3,483,530
Alberta	3,586,573	35,336,368	4,118,747	40,973,616
British Columbia	4,637,011	45,976,127	6,547,098	72,066,655
Total	10,706,282	108,268,335	12,520,828	133,009,125
Subbituminous				
Alberta	4,425,731	7,081,913	4,905,690	10,089,562
Lignite				
Saskatchewan	3,300,186	6,376,929	3,282,798	6,551,991
All types, Canada total	18,432,199	121,727,177	20,709,316	149,650,678

Source: Statistics Canada.
^{p}Preliminary.
[1]Includes production of clean coal and shipments of raw coal from the mine.

Table 2. Canada, coal production, imports, exports and consumption, 1962-72

	Production	Imports[1]	Exports	Domestic Consumption
	(short tons)			
1962	10,216,618	12,614,189	893,919	22,419,224
1963	10,541,623	13,370,406	1,054,367	23,774,032
1964	11,219,311	14,989,114	1,291,664	24,731,197
1965	11,500,069	16,595,393	1,225,994	25,835,511
1966	11,179,873	16,436,755	1,228,820	25,290,069
1967	11,141,334	16,114,190	1,338,353	24,986,330
1968	10,989,007	17,046,745	1,447,012	27,317,782
1969	10,671,879	17,347,404	1,377,872	26,455,330
1970	16,604,164	18,863,779	4,391,572	29,757,279
1971	18,432,199	18,136,181	7,733,775	28,466,201
1972^p	20,709,718	19,264,893	8,513,403	. .

Source: Statistics Canada.
[1]Imports from United States and United Kingdom – coal for consumption.
^{p}Preliminary; . . Not available.

60-cubic-yard dragline, the largest in Canada.

Kaiser Resources Ltd. made steady progress during 1972 towards reaching its full production capability. However, production was hampered during the first quarter by severe winter weather which disrupted rail movement of coal to the Roberts Bank port and by the aftereffects of fire that shut down the preparation plant in late December and early January. The seamen's strike in Japan which lasted from May 5 to mid-July also severely curtailed Kaiser's shipments to Japan. Kaiser, in 1972, renegotiated its contract with Mitsubishi Corporation which resulted in higher prices being given for coal. In September, Kaiser's technical difficulties had been solved to the degree that it established a monthly production record of 457,000 long tons of clean coal.

Exploration for coking coal in British Columbia slowed in 1972, compared to the high levels of the previous two years. This is attributed largely to the softening of coal demand in Japan. Nevertheless, at the end of 1972 approximately 1,700 coal licences covering 1 million acres in the province continued to be held by about 45 companies or consortiums. Of the total, only a few companies stand out as having done substantive development work and investigation of market possibilities. Included are Crows Nest Industries Limited and Emkay Canada Natural Resources Ltd., which are in southern British Columbia, and Brameda Resources Limited (Coalition Mining Limited) and Denison Mines Limited in the northern part of the province northeast of Prince George.

Alberta. Most of Alberta's coal resources are bituminous and subbituminous, but coal of all ranks from lignite to anthracite occurs in the province. Subbituminous coal is found in the Plains region whereas bituminous coal, much of which is of good coking quality, is located in the mountain and foothill belts. Alberta is Canada's leading coal-producing province and has the greatest number of coal mines, although many are small mines with production less than 25,000 tons a year.

In the past, many of the small mines supplied local markets but were forced to shut down because of competition from petroleum and natural gas. Because emerging markets are fewer but larger, the current trend is to larger but fewer mines to meet these expanding markets.

Of the four mines which produce coking coal in Alberta, McIntyre Porcupine Mines Limited is the largest. Before the end of 1971, because of the unsuitability of the longwall mining system to McIntyre's No. 2 and No. 5 mines, the company decided to replace the longwall equipment with continuous miners and shuttle cars. The new mining system was established early in 1972. Also in 1972, the No. 8 surface mine began to produce at its capacity of one million tons annually. However, McIntyre began investigating the possibility of starting a new surface mine to replace No. 8 which has reserves for only two or three additional years. Although total raw coal production by all McIntyre operations was higher in 1972 than in 1971, clean coal shipments were below the contracted level by approximately 25 per cent. This shortfall was attributed in part to the unsatisfactory operation of the preparation plant, which averaged an estimated 65 per cent recovery, but McIntyre was affected, of course, by the seamen's and longshoremen's strikes that affected most coal exporters.

The tentative contract, which McIntyre began to negotiate in 1971 with Japanese steel companies, was cancelled in 1972. This contract called for the delivery of an additional 45.7 million long tons of coal over 15 years.

McIntyre perhaps more than most of the other new coking coal mines in the west, has had difficulty in obtaining certified coal miners. As a result, the company with government help is training new mining personnel. In conjunction with the Division of Vocational Education of Alberta it has developed an 8-week pre-employment training program at the mine site and in conjunction with the federal Department of Manpower and Immigration, it has developed a 32-week on-the-job training program.

During 1972 Cardinal River Coals Ltd. produced coking coal at its full rated production capacity of 1 million tons annually. Shipments to Japan were at contracted levels as the company overcame the effects of the two shipping strikes. During the year the company continued to seek new markets which would allow it to increase production from 1 million to 1.5 million long tons a year which the mine is capable of producing.

The Canmore Mines, Limited, which operates a small mine west of Calgary, continued to produce small quantities of coal for export. The company expects to ship about 200,000 tons to Japan in 1973. This company, which employs 150 persons, is presently investigating new markets for its coal, which is basically a semianthracite coal.

Coleman Collieries Limited, under its contract, was scheduled to ship 1.5 million long tons to Japan from its mine in southwestern Alberta. However, because of operating problems the company discontinued mining at its Vicary North underground mine and at its Tent Mountain and Racehorse surface mines in 1972, and conducted negotiations with its Japanese customers to temporarily reduce its annual shipments from 1.5 million long tons to the rate of 1 million long tons. The Japanese agreed to an 18-month reduction in shipments while Coleman implements a new mining plan and increases production capability at its Vicary South mine.

Exploration for coking coal in Alberta, as in British Columbia, slackened only slightly in 1972 compared with 1971. Exploration companies particularly active during 1972 include: Master Explorations Ltd., Consolidation Coal Company of Canada, Canpac Minerals Limited and Bralorne Resources Limited.

At the end of 1972 subbituminous coal was mined at three main localities in Alberta with the bulk being produced in the Lake Wabamun district, 40 miles west of Edmonton. Calgary Power Ltd., with two power plants at Lake Wabamun, contracts with Manalta Coal Ltd. to mine the coal from its two mines, Whitewood and Highvale. The Highvale mine, newest in the province, was being geared for expansion from the 1972 production level of 1.2 million to 2.4 million tons by 1974. In the Forestburg area, two subbituminous mines were also being expanded to meet the future requirements of Alberta Power Limited's Battle

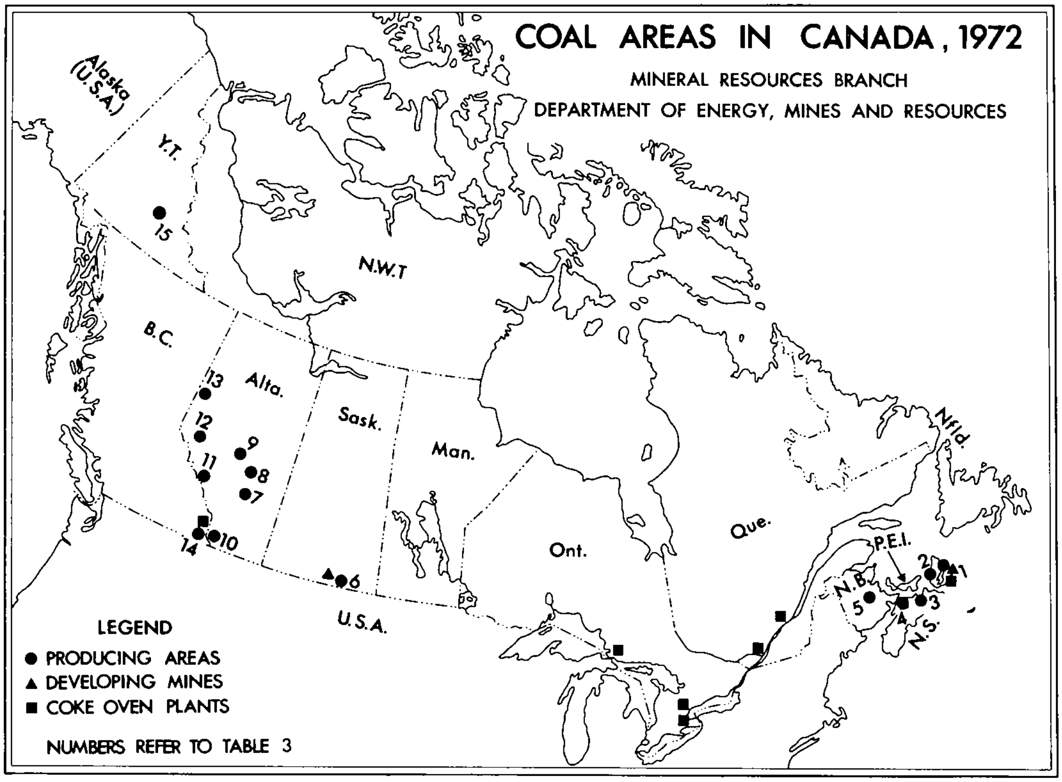


Table 3. Principal coal producers in 1972

Company and Mine Location	Estimated Annual Production	Coal Rank	Chief Markets	Remarks
	(st)			
Nova Scotia				
1. Cape Breton Development Corporation				
No. 12, New Waterford	387,000	Hvb A	Power Generation Industrial Residential	Underground
Lingan Mine, Lingan	19,000	Hvb A	Power Generation, temporary	Underground; began operation in 1972, will expand to 2m tpy by 1974
No. 26, Glace Bay	596,000	Hvb A	Industrial Metallurgical	Underground

Table 3 (cont'd)

Company and Mine Location	Estimated Annual Production	Coal Rank	Chief Markets	Remarks
Princess, Sydney Mines	272,000	Hvb A	Power Generation Industrial Residential	Underground
2. Evans Coal Mines Limited St. Rose	30,000	Hvb C	Power Generation Residential	Underground
3. Drummond Coal Company Limited, Drummond, Westville	27,000	Mvb & Hvb A	Power Generation	Underground
3. Thorburn Mining Limited McBean, Thorburn	45,000	Mvb & Hvb A	Power Generation Industrial Residential	Underground; closed permanently in June
4. River Hebert Coal Company Limited	34,000	Hvb A	Power Generation	Underground
New Brunswick				
5. N.B. Coal Limited Minto, Chipman areas	474,000	Hvb A	Power Generation Paper Mills	Surface; operates at 7 locations
Saskatchewan				
6. Manitoba and Saskatchewan Coal Company (Limited) M & S Mine, Bienfait	625,000	Lig A	Power Generation Industrial	Surface
6. Battle River Coal, Division of Manalta Coal Ltd. Klimax Mine, Estevan	475,000	Lig A	Power Generation Industrial Residential	Surface
6. Utility Coals Ltd. c/o Manalta Coal Ltd. Utility Mine, Estevan	2,135,000	Lig A	Power Generation	Surface
Alberta				
Subbituminous mines				
7. Century Coals Limited Atlas, East Coulee	54,000	Sub B	Residential	Underground
8. Battle River Coal, Division of Manalta Coal Ltd. Vesta Mine, Halkirk	550,000	Sub C	Power Generation Residential	Surface
8. Forestburg Collieries Limited Diplomat Mine, Forestburg	610,000	Sub C	Power Generation Residential	Surface
9. Star-Key Mines Ltd. Star-Key Mine, St. Albert	21,000	Sub C	Residential Industrial	Underground
9. Manalta Coal Ltd. Whitewood Mine, Wabamun	2,250,000	Sub A & B	Power Generation Residential	Surface

Table 3. (concl'd)

Company and Mine Location	Estimated Annual Production	Coal Rank	Chief Markets	Remarks
Highvale Mine, Wabamun	1,304,000	Sub C	Power Generation	Surface
Bituminous mines				
10. Coleman Collieries Limited Vicary Creek, Coleman	722,000	Mvb	Japan for coke-making	Underground
Tent Mountain and Racehorse, Coleman	286,000	Mvb	Japan for coke-making	Surface
11. The Canmore Mines, Limited Canmore	200,000	An & Lvb	Japan, Europe, for coke-making Residential	Surface and Underground
12. Cardinal River Coals Ltd. Cardinal River Mine, Luscar	1,210,000	Mvb	Japan for coke-making	Surface
13. McIntyre Porcupine Mines Limited Smoky River Mines, Grande Cache	2,837,000	Lvb	Japan for coke-making	Underground and Surface; shut No. 2 UG in early January 1973
British Columbia				
14. Kaiser Resources Ltd. Michel Colliery, Natal	1,025,000	Lvb	Japan for coke-making Residential	Underground (hydraulic mining)
Balmer Strip, Natal	5,282,000	Lvb	Japan for coke-making	Surface
14. Fording Coal Limited Fording Mine, Fording Valley	1,009,000	Lvb	Japan for coke-making	Surface, began operations in April 1972
Yukon				
15. Anvil Mining Corporation Limited Tantalus Butte Coal Mine Carmacks	21,000	Sub	Anvil lead-zinc mine for heating and concentrate drying	Underground

Source: Data supplied to the Mineral Resources Branch by companies.
An – Semianthracite; Lvb – Low volatile bituminous; Mvb – Medium volatile bituminous; Sub – Subbituminous; Lig – Lignite; UG – Underground; Hvb – High volatile bituminous.

River generating station located there.

The future of the subbituminous coal industry in Alberta appears assured if only on the basis of the province's significant resources and the fact that much is amenable to surface mining operations. However, the Alberta Energy Resources Conservation Board's opinion that the province's coal resources should be utilized for thermal electric generation rather than oil and gas is further evidence of an enlarged industry in the future. In general, thermal electric plants located

Table 4. Canada, coal production[1] by type of mining and average output per man-day, 1972

	Production		Average Output per Man-day	
	Underground	Surface	Underground	Surface
	(short tons)			
Nova Scotia	1,555,060	–	2.4	–
New Brunswick	–	429,544	–	7.6
Saskatchewan	–	3,282,798	–	55.2
Alberta	2,581,629	7,875,471	7.7	45.9
British Columbia	1,029,608	8,045,378	9.8	16.0
Canada 1972^p	5,166,297	19,633,191	6.5	34.4
1971	4,638,568	13,793,631	4.5	39.5
Total, all mines				
1972^p	24,799,488		28.6	
1971	18,432,199		30.7	

Source: Statistics Canada.
[1]Production statistics for 1971 and 1972 in this table are not comparable, due to change in reporting procedures by Statistics Canada.
^{p}Preliminary; – Nil.

COAL'S ROUTE TO CONSUMPTION

MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES

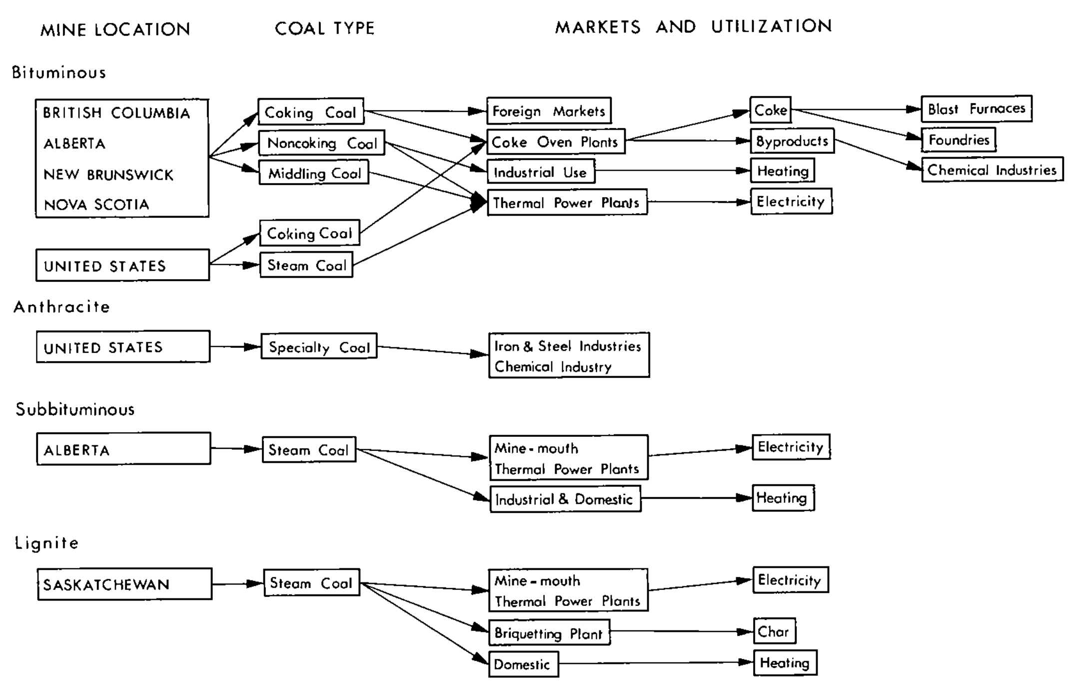


Table 5. Regional Canadian coal shipments[1], 1972

	Originating Province					
Destination	Nova Scotia	New Brunswick	Sask.	Alberta	British Columbia and Yukon	Canada
			(short tons)			
Railways in Canada	10,678	–	107,927	21	–	118,626
Newfoundland	8,694	–	–	–	–	8,694
Prince Edward Island	18,201	–	–	–	–	18,201
Nova Scotia	1,181,136	57,827	–	–	–	1,238,963
New Brunswick	28,366	316,573	–	–	–	344,939
Quebec	70,189	67,524	–	805	–	138,518
Ontario	15,488	–	32,523	47,935	–	95,946
Manitoba	–	–	711,615	113,048	–	824,663
Saskatchewan	–	–	2,421,510	72,116	–	2,493,626
Alberta	–	–	–	4,758,869	–	4,758,869
British Columbia	–	–	–	42,680	279,829	322,509
Total, Canada	1,332,752	441,924	3,273,575	5,035,474	279,829	10,363,554
United States	–	–	7,859	4,021	302	12,182
Japan	–	–	–	3,603,464	5,695,029	9,298,493
Other	71,597	–	–	–	38,876	110,473
Total shipments	1,404,349	441,924	3,281,434	8,642,959	6,014,036	19,784,702

Source: Statistics Canada.
– Nil.
[1]Includes shipments of raw coal and clean coal.

at coal mine sites can provide fuel at lower costs on a Btu basis than can either of Alberta's natural gas or oil. For example, subbituminous coal costs around 8 to 10 cents per million Btu at the plant whereas the average field price for gas in Alberta is over 16 cents per million Btu.

Saskatchewan. Lignite production in Saskatchewan in the last half of the 1960's was stabilized at about 2 million tons annually. However, in 1970 production was increased and output since then has been better than 3 million tons annually.

In 1972, plans for a new lignite mine at Estevan were announced by Manitoba and Saskatchewan Coal Company (Limited), a wholly owned subsidiary of Luscar Ltd. Initial development work was begun in 1972 with start-up scheduled for January 1974 at an annual rate of 1.8 million tons and will raise provincial output to the level of 5 million tons per year. All the coal produced from this mine will be sold to the nearby Boundary Dam power plant of Saskatchewan Power Corporation. Once full production capacity is reached at the new mine, the company will be employing 135 people at its two mines and lignite char plant in the Estevan area.

Because of the growing demand for lignite, the Government of Canada and the Province of Saskatchewan have undertaken a $912,000 shared-cost program to determine the potential for future development of lignite reserves in southern and central Saskatchewan.

New Brunswick. In New Brunswick, the provincial Crown company N.B. Coal Limited produced coal from seven locations within the Minto coalfield. Easily mineable reserves are nearly depleted but small production in the order of 500,000 tons has been maintained in recent years. The coal is used for local electric power production by the New Brunswick Electric Power Commission.

Nova Scotia. High volatile bituminous coal is produced mainly from mines at Sydney, on Cape Breton Island, with some output from the Inverness area also on Cape Breton, and Pictou and Joggins areas on the mainland. The coalfields in Nova Scotia, many of which are beneath the ocean floor, are Carboniferous and contain the oldest coal measures which are produced in Canada. Some of the Sydney area coal makes satisfactory coke and the coke market along with thermal power generation constitutes the chief markets for Nova Scotia coal.

In early 1972, the Cape Breton Development Corporation (Devco) announced the formal closing of the No. 20 colliery at Glace Bay. This mine had been idle since July 1971 pending the outcome of a study to evaluate its future. The results of the study indicated that even with large capital expenditures the mine could not be operated economically and there were concerns for safety. The No. 20 mine began production in 1939 and operated continuously until 1971. All equipment was salvaged and moved to Devco's three other mines in the area. In October, Devco began preproduction mining at its new Lingan mine near New Waterford. The preproduction at Lingan is being obtained by room-and-pillar mining using a continuous miner and shuttle car. In 1973, Devco expects the room-and-pillar system will produce about 400,000 to 500,000 tons of coking coal. This system will be used in Lingan until 1974 when sufficient depths will be reached below the ocean floor to permit longwall mining at a production rate of 1.5 to 2 million tons annually.

In 1972, a two-year $500,000 research program was begun to evaluate methods of economically reducing the sulphur content of Cape Breton coal. This program was undertaken by the Mines Branch of the Department of Energy, Mines and Resources. Also during 1972, the federal government approved the spending of $40 million over five years to rehabilitate three established coal mines on Cape Breton Island: No. 12 at New Waterford, No. 26 at Glace Bay and the Princess colliery at North Sydney. A new preparation plant is also part of this program. Devco officials hope that with these improvements the Sydney area coal industry can begin to cover its true operating costs within five years.

In June, Thorburn Mining Limited, which was formed in 1968 by Pictou County Research and Development Commission, permanently closed its McBean coal mine on the Nova Scotia mainland. This mine operated for many years on financial assistance from both federal and provincial governments.

Trade and markets

Exports. A total of 8.5 million tons of bituminous coal having a value of $106 million was exported in 1972 to seven countries. Of this, 61 per cent originated in British Columbia and 38 per cent in Alberta. Approximately 41 per cent of Canadian production

Table 6. Canada, exports and imports of coal, 1971-72

	1971		1972^{p}	
	(short tons)	($)	(short tons)	($)
Exports				
Japan	7,407,898	82,063,000	8,322,937	103,835,000
Chile	–	–	101,099	1,260,000
Belgium-Luxembourg	66,069	755,000	77,827	716,000
United States	10,614	112,000	9,940	107,000
St. Pierre-Miquelon	409	9,000	1,585	35,000
United Kingdom	19,602	359,000	10	*
West Germany	–	–	5	*
Italy	155,851	2,440,000	–	–
France	73,332	825,000	–	–
	7,733,775	86,563,000	8,513,403	105,953,000
Imports (for consumption)				
Anthracite				
United States	404,231	6,124,000	379,347	5,946,000
Bituminous				
United States	17,731,950	144,889,000	18,885,546	172,341,000
Total	18,136,181	151,013,000	19,264,893	178,287,000

Source: Statistics Canada.
^{p}Preliminary; – Nil; * Less than $1,000.

Table 7. Export contracts of coking coal to Japan

Company	Annual Shipments	Term	Present Price[1] fob Port	Coal Quality Specifications						Importers/ Trading Companies
				TM	Ash	VM	TS	FSI	Size	
	(millions of long tons)		(U.S. $)	(%)	(%)	(%)	(%)			
McIntyre Porcupine Mines Limited	1.25	1973-74	21.95	6.0	7.0	17.5	0.5	7/9	1½" max	Mitsubishi, Marubeni Sumitomo, Nissho-Iwai Kawatetsu
Cardinal River Coals Ltd.	1.0	1970-84	14.30	6.0	8.5	24/26	0.37	5/7	1½" max	Mitsui C. Itoh
The Canmore Mines, Limited	0.15	1968-77	14.88	6.0	9.0	16/17	0.6	6/8		Toyo Menka
Coleman Collieries Limited	1.0	1967-82	18.73	5.0	9.5	20/23	0.6	6	2" max	Marubeni Toyo Menka
Fording Coal Limited	3.0	1972-86	17.73	6.0	8.0	21/24	0.45	5/7	1½" max	Mitsui Marubeni
Kaiser Resources Ltd.	4.5	1973-85	18.73[2]	6.0	9.5	19/22	0.4	6/8	90% -½ in.	Mitsubishi Mitsubishi

[1] As of May 15, 1973. [2] Will increase to $19.85 (Cdn) on July 1, 1973.
TM – Total moisture; VM – Volatile matter; TS – Total sulphur; FSI – Free swelling index.

Table 8. Canada, supply and demand of coal, 1961 and 1971

	1961	1971
	(short tons)	
Supply		
Production	10,335,779	18,432,199
Landed imports	12,132,449	17,831,663
Total inventory change	-265,166	+63,886
Total supply	22,733,394	36,199,976
Demand		
Domestic sales		
Electric utilities	2,253,398	17,213,408
Mining and manufacturing	7,688,228	2,509,650
Coke-making	5,330,542	7,341,833
Subtotal	15,272,168	27,064,891

	1961	1971
	(short tons)	
Residential	4,026,780	368,023
Railways	476,752	124,401
Ship's bunker	252,111	149,487
Government and institutional	320,000	125,000
Subtotal	5,075,643	766,911
Coal mine and local use	889,472	387,899
Unaccounted-for coal	556,775	246,500
Total domestic demand	21,794,058	28,466,201
Exports	939,336	7,733,775
Total demand	22,733,394	36,199,976

Source: Statistics Canada.

was exported in 1972 and this proportion is expected to remain fairly constant, with increases in production of coal for domestic power generation keeping pace with growth in production for export. Japan received 98 per cent or 8.3 million tons of Canadian coal in 1972 compared with 96 per cent or 7.4 million tons in 1971. Canada supplied 16 per cent of Japan's total coal imports during 1972. All coal shipped to Japan was of coking quality. Spot shipments totalling about 200,000 tons of steam coal were made to Chile, Belgium-Luxembourg and the United States. The Nova Scotian shipment to Chile was the first Canadian coal to be delivered to that country. A small quantity of lignitic coal was exported from Saskatchewan to the United States but the quantity supplied to this market has been dwindling and it continued to decline in 1972.

Imports. Canada imported 18.9 million tons of bituminous coal and 400,000 tons of anthracite coal in 1972, all from the Appalachian region of the United States. Imports were up by 1 million tons because consumers were rebuilding stockpiles which were reduced during the six-week bituminous coal miners' strike in the United States in 1971. Over 90 per cent of the imported coal was for Ontario with the remainder going primarily to Quebec and Nova Scotia. Bituminous coal used for thermal power generation accounted for slightly over 50 per cent of total imports. Such coal is purchased largely under long-term contracts by The Hydro-Electric Power Commission of Ontario (Ontario Hydro). About 50-55 per cent of coking coal for the steel companies comes from captive mines in the United States; the remainder is purchased from U.S. coal companies.

Thermal power industry

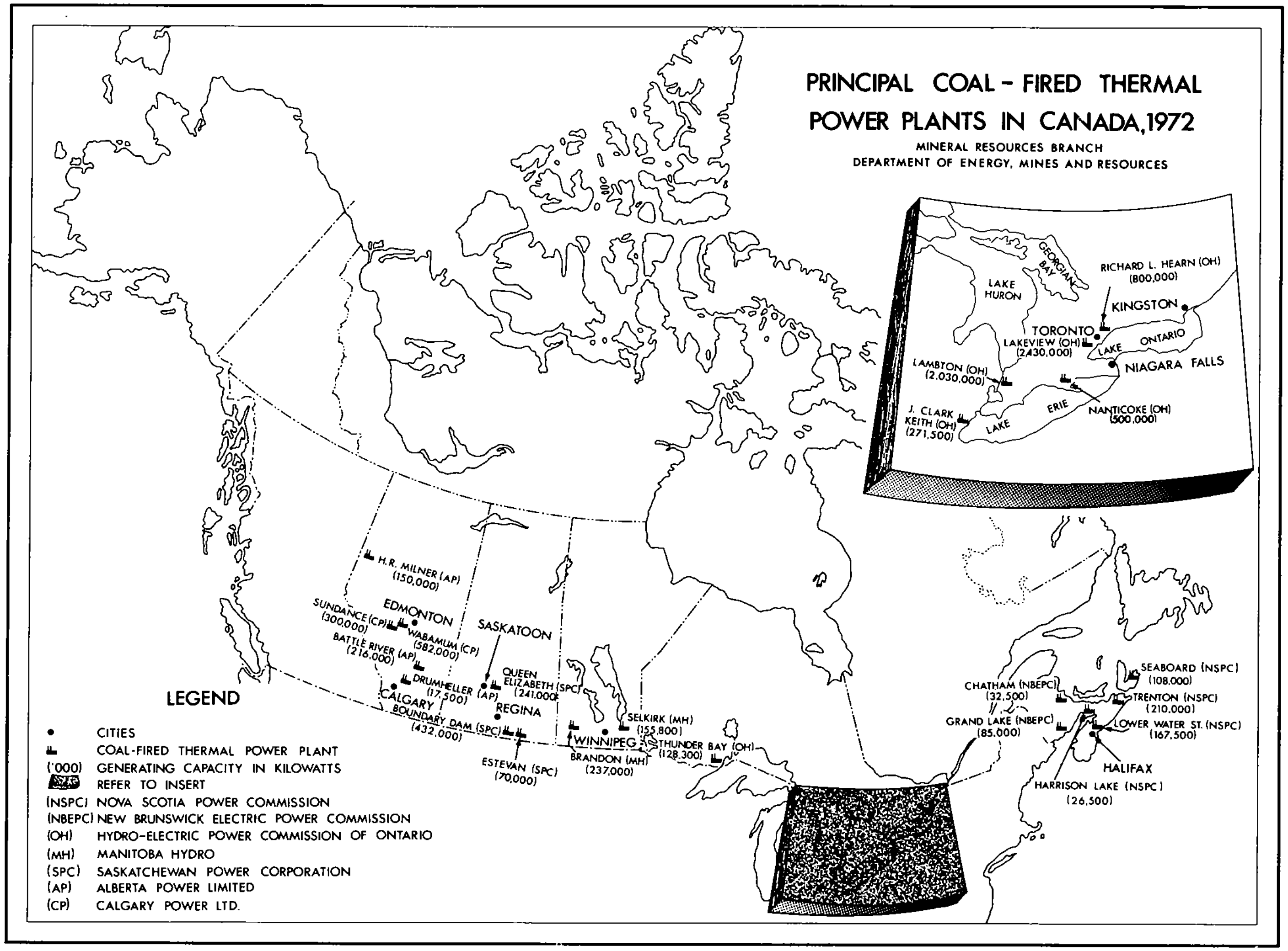
Coal used for thermoelectric power generation totalled 16.8 million tons in 1972, down slightly from the 17.2 million tons of coal consumed by this industry in 1971. At the end of 1972, existing coal-fired electric power plants had a combined total capacity of 9,190 megawatts (MW). In addition, utility companies in several provinces have announced plans which will result in the construction of thermal plants totalling about 5,240 MW of capacity to be completed within six years. This expansion is expected to occur principally in Ontario and to a lesser extent in Alberta and Saskatchewan. Of the 16.8 million tons of coal used for power generation in 1972, it is estimated that about 8.4 million tons were of domestic coal and the remainder imported coal for Ontario Hydro.

Ontario Hydro, the largest consumer of coal for electricity generation in Canada, purchases its basic

Table 9. Canada, coal used by thermoelectric generating stations by provinces, 1957-1972

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskatchewan	Alberta	Total, Canada
			(thousands of short tons)				
1957	459	213	724	1	303	–	1,700
1958	431	144	317	98	375	–	1,365
1959	426	141	196	34	435	187	1,419
1960	494	202	118	56	770	206	1,846
1961	504	168	272	116	964	229	2,253
1962	515	121	1,493	111	1,129	356	3,725
1963	534	107	2,807	66	1,054	582	5,150
1964	584	245	3,081	145	1,109	1,101	6,265
1965	698	368	3,932	193	1,196	1,335	7,722
1966	881	324	3,858	87	1,230	1,499	7,879
1967	835	303	4,889	42	1,471	1,573	9,113
1968	712	264	6,088	197	1,492	2,346	11,099
1969	745	165	7,082	56	1,238	2,621	11,907
1970	604	125	8,483	555	2,170	3,253	15,190
1971	759	299	9,436	492	2,200	4,027	17,213
1972[p]	760	325	8,377	430	2,422	4,507	16,821

Source: Statistics Canada.
[p]Preliminary; – Nil.



PRINCIPAL COAL - FIRED THERMAL POWER PLANTS IN CANADA, 1972
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
LAKE HURON
GEORGIAN BAY
RICHARD L. HEARN (OH) (800,000)
KINGSTON
TORONTO
LAKEVIEW (OH) (2,430,000)
LAKE ONTARIO
NIAGARA FALLS
LAMBTON (OH) (2,030,000)
J. CLARK KEITH (OH) (271,500)
LAKE ERIE
NANTICOKE (OH) (500,000)
H.R. MILNER (AP) (150,000)
EDMONTON
SUNDANCE (CP) (300,000)
WABAMUN (CP) (582,000)
BATTLE RIVER (AP) (216,000)
SASKATOON
QUEEN ELIZABETH (SPC) (241,000)
DRUMHELLER (AP) (17,500)
CALGARY
REGINA
BOUNDARY DAM (SPC) (432,000)
ESTEVAN (SPC) (70,000)
SELKIRK (MH) (155,800)
WINNIPEG
BRANDON (MH) (237,000)
THUNDER BAY (OH) (128,300)
SEABOARD (NSPC) (108,000)
CHATHAM (NBEPC) (32,500)
TRENTON (NSPC) (210,000)
GRAND LAKE (NBEPC) (85,000)
LOWER WATER ST. (NSPC) (167,500)
HALIFAX
HARRISON LAKE (NSPC) (26,500)
LEGEND
CITIES
COAL-FIRED THERMAL POWER PLANT
('000) GENERATING CAPACITY IN KILOWATTS
REFER TO INSERT
(NSPC) NOVA SCOTIA POWER COMMISSION
(NBEPC) NEW BRUNSWICK ELECTRIC POWER COMMISSION
(OH) HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO
(MH) MANITOBA HYDRO
(SPC) SASKATCHEWAN POWER CORPORATION
(AP) ALBERTA POWER LIMITED
(CP) CALGARY POWER LTD.

requirements of coal under long-term contracts with coal companies in northwest Virginia and Pennsylvania. Anticipated demand above this base is met by spot purchases. Ontario Hydro uses coal at six power plants that had a combined capacity of 6,200 MW in 1972 and used 8.4 million tons of coal. In 1972, Ontario Hydro's first of eight 500-megawatt units began operating at its Nanticoke generating station near Port Dover on Lake Erie. When all eight units are in operation it will be the largest coal-fired generating station in Canada. During the year, four 100-MW units at Ontario Hydro's Richard L. Hearn Generating Station in Toronto were converted to burn only natural gas. Four 200-MW units can burn either gas or coal, or both in combination, the choice being governed largely by atmospheric conditions but also by fuel supply conditions.

During 1971-72 investigations were renewed to study the possibility of using the lignitic coal at Onakawana in northeastern Ontario as a fuel for thermal power generation. Survey and drill teams were moved into the James Bay area to determine the extent of the lignite beds.

A total of 2.8 million tons of Saskatchewan lignite was used for power generation in both Saskatchewan and Manitoba in 1972. Lignite consumption in Saskatchewan has had 12 years of substantial growth in which lignite used for power generation increased from 435,000 to over 2.4 million tons in 1972. There is every evidence that the increase will continue. In Saskatchewan's Estevan area, work was nearly completed on the third 150-MW unit with start-up scheduled for July 1973. Upon completion of this unit, the Boundary Dam Station will be one of the largest lignite-fired power plants in North America. A sixth unit of 300-MW capacity is scheduled to be operational in 1977. A new mine in the Estevan area will begin operating in January 1974 to supply approximately half of the future coal requirements of the Boundary Dam Generating Station at Estevan over the next 15 years. The agreement to mine the necessary coal was signed with Manitoba and Saskatchewan Coal Company (Limited). The existing agreement with Utility Coals Ltd. to supply the other half of the Boundary Dam coal requirements was extended to 1978.

In Manitoba, at Brandon and Selkirk, two lignite-fired generating stations having a combined capacity of 392 MW, used approximately 430,000 tons of lignite in 1972.

In Alberta, Calgary Power Ltd. continued to operate two power plants on Lake Wabamun, 40 miles west of Edmonton. Both plants use subbituminous coal from mines adjacent to the plants. The second plant, Sundance, began operation in 1970 with its first 286-MW unit. A second 286-MW unit is under construction and is scheduled for operation in late 1973. Approximately 1.4 million tons of subbituminous coal a year will be required for each unit. Based on an ultimate capacity of about 1,300 MWe from four units tentatively planned for the Sundance Station, the adjacent mine will need a production capacity of from 5 to 6 million tons of coal a year.

At Grande Cache, Alberta Power Limited's 150-MW thermal power plant designed to use oxidized and middling coal from the nearby McIntyre mining operations was being readied for operation at the end of 1972. It began producing electricity in early 1973. This plant will consume between 300,000 and 400,000 tons of coal annually. Alberta Power is also installing a 150-MW unit at the Battle River Station at Forestburg, which will bring the total generating capacity of the station to 362 MW.

Coke industry

In 1972 approximately 7.3 million tons of coking coal were carbonized to produce 5.2 million tons of coke. About 90 per cent of the coking coal used to make coke in Canada was imported from the United States. The three steel companies that operate coke oven plants in Hamilton and Sault Ste. Marie have captive coal mines in the United States and use United States coal exclusively. In Sydney, Nova Scotia, DEVCO uses a combination of Nova Scotia and United States coal to produce and supply the nearby steel mill with coke.

Of the 6.8 million tons of coking coal imported from the United States in 1972, it is estimated that 3.8 million tons or 55 per cent came from captive mines.

Approximately 4.4 million tons, or 85 per cent of the coke produced in Canada is charged to blast furnaces for pig iron production. The remainder of the coke is consumed by foundries, chemical plants and nonferrous smelters. Coke trade has been small, as illustrated by the 262,877 tons of coke valued at $5 million that were exported in 1972 to five countries of which the United States was the largest purchaser. In 1972 Canada imported 500,000 tons valued at $17.7 million. Recovery of coking coal byproducts such as coke oven gas, ammonia, tar and light oils is a small industry in Canada because they are readily available as petroleum-based products.

In 1972 an average of 1.4 tons of coking coal was required for each ton of coke produced in Canada. The coke rate, the amount of coke consumed per ton of pig iron produced, was 1,060 pounds in 1972, down slightly from the rate in 1971. Based on the coking rate and the amount of coal required for each ton of coke, it is estimated that in 1972 about 1,520 pounds (0.76 ton) of coking coal were required per ton of pig iron produced in Canada.

About 95 per cent of the coke produced in Canada is manufactured in standard slot-type ovens at coke oven plants in Ontario, Nova Scotia and Quebec. The three largest coke oven plants are owned and operated by integrated steel companies, The Algoma Steel Corporation, Limited, The Steel Company of Canada, Limited, and Dominion Foundries and Steel, Limited.

Table 10. Coke oven and other carbonization plants in Canada

Coke Plant	Battery and No. of Ovens	Oven Type	Year Built	1972 Plant Capacity	1972 Coke Production	Byproducts
				(thousands of tpy)		
The Agloma Steel Corporation, Limited, Sault Ste. Marie, Ontario	No. 5 – 86	Koppers-Becker Underjet	1943	2,100	1,515	Naphthalene, light oil, gas, tar
	No. 6 – 57	Koppers-Becker Underjet	1953			
	No. 7 – 57	Wilputt Underjet	1958			
	No. 8 – 60	Wilputt Underjet	1967			
	No. 9 –		*			
The Steel Company of Canada, Limited, Hamilton, Ontario	No. 3 – 61	Wilputt Underjet	1947	3,400	1,784	Tar, sulphate of ammonia, sodium phenolate, gas, light oil
	No. 4 – 83	Wilputt Underjet	1952			
	No. 5 – 47	Wilputt Underjet	1953			
	No. 6 – 73	Otto Underjet	1967			
	No. 7 – 83	Otto Underjet	1972			
Dominion Foundries and Steel, Limited, Hamilton, Ontario	No. 1 – 25	Koppers-Becker Gun Type Comb	1956	1,800	1,122	Tar, light oil, gas, ammonium sulphate, sulphur
	No. 2 – 35	Koppers-Becker Gun Type Comb	1951			
	No. 3 – 45	Koppers-Becker Gun Type Comb	1958			
	No. 4 – 53	Koppers-Becker Gun Type Comb	1967			
	No. 5 – 53	Koppers-Becker Gun Type Comb	1971			
Cape Breton Development Corporation, Sydney, Nova Scotia	No. 5 – 53	Koppers-Becker Underjet	1949	900	300	Tar, crude oil, gas
	No. 6 – 61	Koppers-Becker Underjet	1953			
Gaz Metropolitain, inc., Ville La Salle, Quebec	No. 1 – 59	Koppers-Becker	1928	626	na	Tar, light oil, gas
	No. 2 – 15	Koppers-Becker	1947			
Manitoba and Saskatchewan Coal Company (Limited), Char and Briquetting Division Bienfait, Saskatchewan	2 units	Lurgi carbonizing retort	1925	110	na	Creosote, lignite, tar, lignite pitch
Kaiser Resources Ltd. Natal, British Columbia	10 units	Curran-Knowles	1939	245	na	Crude tar, gas
	10 units	Curran-Knowles	1943			
	16 units	Curran-Knowles	1949			
	16 units	Curran-Knowles	1952			
	3 units	Mitchell	1963			

na Not available. *New Battery under construction

Table 11. Canada, coal coke production and trade, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Production				
Ontario	4,288,288	*	4,457,591	*
Other provinces	817,504	*	696,669	*
Total	5,105,792	*	5,154,260	*
Imports				
United States	459,171	14,928,000	379,907	13,196,000
West Germany	187,257	7,219,000	128,091	4,499,000
Japan	–	–	1,025	41,000
United Kingdom	–	–	42	4,000
Total	646,428	22,147,000	509,065	17,740,000
Exports				
United States	184,125	4,862,000	170,803	4,022,000
Netherlands	79,285	981,000	74,830	809,000
West Germany	23,410	224,000	14,850	106,000
Spain	7,783	340,000	2,180	22,000
St. Pierre-Miquelon	–	–	193	4,000
Panama	–	–	21	1,000
Belgium-Luxembourg	13,955	113,000	–	–
Norway	8,978	136,000	–	–
Dominican Republic	229	8,000	–	–
Total	317,765	6,664,000	262,877	4,964,000

Source: Statistics Canada
*Practically all coke production is used by producers in the iron and steel industry and is not given a value.
^{p}Preliminary; – Nil.

Table 12. Canada, coke production and trade, 1962-1972

	Production		Imports		Exports	
	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke
	(short tons)					
1962	4,021,774	201,985	247,304	338,068	126,024	31,858
1963	4,280,797	199,636	234,610	369,037	136,316	18,016
1964	4,342,982	206,815	315,763	440,607	85,969	21,225
1965	4,368,791	242,813	569,905	413,047	71,531	17,101
1966	4,426,051	230,119	584,965	499,154	77,952	9,668
1967	4,430,299	227,886	387,049	565,836	65,292	18,641
1968	5,310,762	238,601	255,405	561,407	143,771	5,740
1969	5,002,275	231,679	280,905	703,582	272,997	2,606
1970	5,668,219	207,649	394,953	779,079	273,890	53,289
1971	5,105,792	206,439	646,428	733,890	317,765	12,314
1972^p	5,154,260	267,167	509,065	612,565	262,877	971

Source: Statistics Canada.
^{p}Preliminary.

The Algoma Steel Corporation, Limited (Algoma) has one of the largest coke-making plants in Canada, located at Sault Ste. Marie, Ontario. In 1972 construction began on a new coke oven battery (No. 9) and auxiliary equipment in part to replace an old battery and to add coke-making capacity required for greater raw steel production. This new plant will be ready for production in 1975. To ensure a continuing supply of coking coal, Algoma is developing a new, low volatile, coal mine at Fairdale, West Virginia. Production of coal from this mine is expected to start in 1974 and to be increased gradually to a rate of 1.25 million tons per annum by early 1977. This tonnage will exceed requirements for coke-making for several years. An agreement was entered into under which a total of 5 million tons will be sold to another Canadian steel producer over 12 1/2 years starting in 1975.

The Steel Company of Canada, Limited (Stelco) imports the bulk of its coking coal from subsidiary mines in the United States for its coke oven plant in Hamilton, Ontario. In 1972 Stelco completed a new battery of 83 coke ovens. These ovens increased Stelco's ovens to 347 and expanded coke capacity by 25 per cent, to approximately 2.6 million tons of coke annually requiring about 3.6 million tons of coking coal.

Production at Stelco's new Madison mine in West Virginia began in July at an annual rate of 700,000 tons of high volatile bituminous coking coal. Stelco also acquired a 12 1/2 per cent interest in a company which is developing a low volatile bituminous coal property in West Virginia. Production is scheduled to begin in 1974 and Stelco's share will amount to 187,000 tons annually.

Dominion Foundries and Steel, Limited's (Dofasco), coke oven plant at Hamilton has an annual capacity of 1,312,500 tons of coke. Dofasco's annual coking coal requirements are approximately 1.8 million net tons. About 70 per cent is provided either from long-term contracts or from a property in which Dofasco has an ownership interest. A 20-year agreement was recently negotiated with Eastern Associated Coal Corp. to supply the company with 500,000 tons of coal annually. This is in addition to an established long-term contract under which this company provides Dofasco with approximately 550,000 tons of coal annually. Another principal source is through the company's ownership interest in the Itmann Coal Company of West Virginia where purchases from this mine normally total in excess of 250,000 tons annually.

Cape Breton Development Corporation (DEVCO) at Sydney, Nova Scotia produced 299,000 tons of coke from 409,000 tons of coking coal. In 1972 about 77 per cent of the coal that went into coke production was Nova Scotia coal from Devco's mines and the remainder was imported from the United States. In 1971 Devco implemented a program to repair its old coke ovens so that production can be stabilized at 600,000 tons annually by 1973.

Table 13. World coal production

	1967	1968	1969	1970	1971^{p}
	(thousands of short tons)				
North America	578,944	570,615	584,376	619,929	581,813
South America	8,274	8,395	9,039	9,149	9,259
Europe	1,841,241	1,856,496	1,873,376	1,891,895	1,973,433
Africa	59,154	62,236	63,493	64,154	70,547
Asia	441,024	529,005	560,635	598,224	609,714
Oceania	67,721	73,325	81,020	86,200	83,670
World					
Lignite (estimate)	792,304	811,071	846,023	868,100	1,103,799
Bituminous and anthracite (by subtraction)	2,204,054	2,289,001	2,325,916	2,401,451	2,224,637
Total, all types	2,996,358	3,100,072	3,171,939	3,269,551	3,328,436

Source: U.S. Bureau of Mines.
^{p}Preliminary.

Cobalt

D.D. BROWN

Cobalt continued in ample supply during 1972 and demand strengthened through the year. Estimated noncommunist world production was 48 million pounds. The Republic of Zaïre accounts for about 65 per cent of noncommunist world production; Zaïre, Zambia, Canada, Finland and Morocco together account for about 96 per cent. Since cobalt production is almost entirely obtained as a byproduct in the processing of copper and nickel ores, cobalt output is largely determined by nickel and copper production. To determine the availability of cobalt at any one time is difficult, since producers generally report their shipments and give no indication of their production nor amount of cobalt carried over in inventory at year-end. During 1972, United States government stockpile sales of 8.3 million pounds of cobalt represented a major additional source of supply; government sales by competitive bidding were nearly 10 times greater in 1972 than in the previous year. Producers' prices of electrolytic cobalt remained at U.S.$2.45 a pound through most of 1972.

Production (shipments) of cobalt in all forms in Canada in 1972 was 4,151,000 pounds valued at $10,234,000, compared with 4,323,318 pounds valued at $9,429,564 in 1971. All production was derived as a byproduct of nickel-copper ores.

United States Government sales

The United States General Services Administration (GSA) altered its policy governing sales of cobalt from stocks in 1972 by offering on a monthly sealed-bid basis about 1 million pounds of specification-grade cobalt in various forms each month instead of the 1971 offering of about 2 million pounds a month. An additional 5,015,061 million pounds of subspecification-grade 'Calera' material was offered and sold separately during the year. GSA sales including the Calera cobalt totalled 8,318,349 pounds in 1972 compared with 901,699 pounds of cobalt metal sold the previous year. Government sales of cobalt ranged from U.S. $2.20 to $2.3852 a pound for specification grade and from U.S.$1.925 to $2.156 a pound for subspecification grade. The government stockpile objective remained at 38.2 million pounds and on December 31, 1972 the total stockpile inventory contained about 68.5 million pounds of specification-grade cobalt.

Outlook

Cobalt supply is expected to be more than adequate to meet demands over the next few years. New production from nickel-cobalt laterite deposits is scheduled for 1974 in Australia and the Philippines. Expanded production is forthcoming from Zaïre and Zambian copper-belt producers and from nickel producers in Finland and Australia. United States government stockpile cobalt sales are expected to moderate cobalt prices over the next few years. In the longer term, the price of cobalt will probably be stabilized by an expanded and more diversified supply from new nickel laterite mines and nickel-copper sulphide mines. Manganese nodules on the deep-ocean floor are a possible future source of cobalt as well as manganese, nickel and copper but the timing of initial commercial operations is uncertain.

Canadian developments

Canada's leading producer, The International Nickel Company of Canada, Limited (Inco), recovers cobalt in the form of crude oxide at its nickel refinery at Port Colborne, Ontario, and Thompson, Manitoba. Upgraded cobalt oxide and salts are also recovered at the company's nickel refinery at Clydach, in Wales. During 1972 the company's cobalt deliveries were 2,210,000 pounds compared with 1,980,000 pounds in 1971. Inco's new Copper Cliff nickel refinery was substantially completed by year-end and is scheduled for production in 1973. The refinery will use the Inco pressure carbonyl-process and cobalt carbonate will be recovered. Over half a million pounds of cobalt will be produced as high-purity salts.

Falconbridge Nickel Mines Limited exported nickel-copper matte from its smelter at Falconbridge, Ontario, to the refinery of its subsidiary, Falconbridge Nikkelverk Aktieselskap, at Kristiansand, Norway. The cobalt refinery section of the Nikkelverk refinery was extensively damaged by fire in May 1972 and deliveries of refined cobalt were reduced when production ceased. Output of cobalt-containing residues from the nickel refinery operation was stockpiled for treatment, which was resumed in March 1973.

Sherritt Gordon Mines, Limited recovers cobalt metal powder from nickel refinery end-solutions at its hydrometallurgical refinery at Fort Saskatchewan, Alberta. The refinery treats nickel-copper concentrates

Table 1. Canada, cobalt production, trade and consumption, 1971-72

	1971		1972p	
	(pounds)	($)	(pounds)	($)
Production[1] (all forms)				
Ontario	3,511,207	7,650,337	3,543,000	8,663,000
Manitoba	644,580	1,417,360	608,000	1,571,000
British Columbia	113,545	245,257	–	–
Quebec	53,986	116,610	–	–
Total	4,323,318	9,429,564	4,151,000	10,234,000
Exports				
Cobalt metal				
United States	632,518	1,693,000	809,647	1,973,000
France	27,219	67,000	26,617	70,000
South Africa	30,020	176,000	10,530	25,000
Japan	7,711	44,000	5,868	25,000
Britain	2,132	8,000	3,019	13,000
Argentina	1,600	4,000	4,400	12,000
Belgium and Luxembourg	31,466	33,000	–	–
West Germany	13,200	32,000	–	–
Other countries	2,636	9,000	400	1,000
Total	748,502	2,066,000	860,481	2,119,000
Cobalt oxides and salts[2]				
Britain	–	–	1,386,200	2,072,000
United States	2,466,500	3,351,000	229,500	306,000
Total	2,466,500	3,351,000	1,615,700	2,378,000
Consumption[3]				
Cobalt contained in:				
cobalt metal	126,976	. .		
cobalt oxide	37,011	. .		
cobalt salts	57,007	. .		
Total	220,994	. .	. .	. .

Source: Statistics Canada.
[1] Production (cobalt content) from domestic ores. [2] Gross weight. [3] Available data reported by consumers.
p Preliminary: – Nil; . . Not available.

from Sherritt Gordon's Lynn Lake mine in Manitoba. It also treats concentrates on a toll basis from the Giant Mascot Mines Limited mine near Hope, British Columbia, concentrates from Western Mining Corporation Limited's operations in Western Australia, and nickel matte from Société Le Nickel in New Caledonia. During 1972 Sherritt Gordon Mines refined 117,000 pounds of cobalt from Lynn Lake concentrates and 692,000 pounds from purchased feed. The company sold 713,000 pounds of cobalt compared with 679,000 pounds in 1971.

Cobalt Refinery Division of Kam-Kotia Mines Limited, closed its refinery at Cobalt, Ontario, in February 1972. The company's inventory of cobalt and other metals was liquidated at the beginning of 1971.

World developments

Noncommunist world production of cobalt is expected to increase substantially over the next few years.

There was no *United States* domestic mine production of cobalt in 1972 since cobalt-bearing pyrite concentrates output was discontinued at the end of 1971. American Metals Climax, Inc. (Amax) announced that the Port Nickel, La., nickel refinery near Braithwaite, Louisiana, was being expanded during the year for construction completion in 1974. Substantial quantities of cobalt will be produced as a byproduct of nickel refining operations when the plant starts production in 1974. Initial feed material for the plant will be nickel-copper matte smelted in Botswana, Africa; cobalt will be produced as metal, oxide powder and metal briquettes.

Table 2. Canada, cobalt production, trade and consumption, 1963-72

		Exports		Imports		
	Production[1]	Cobalt Metal	Cobalt Oxides and Salts[2]	Cobalt Ores[2]	Cobalt Oxides[2]	Consumption[3]
			(pounds)			
1963	3,024,965	739,229	1,098,300	2,500	28,291	364,594
1964	3,184,983	593,607	1,654,900	. .	. .	365,851
1965	3,648,332	292,191	1,414,200	. .	. .	366,036
1966	3,511,169	627,990	1,308,300	. .	. .	392,177
1967	3,603,773	1,498,559	1,934,500	. .	. .	293,086
1968	4,029,549	1,210,909	1,646,500	. .	. .	358,098
1969	3,255,623	1,155,291	1,199,800	. .	. .	393,658
1970	4,561,213	839,849	1,845,000	. .	. .	327,030
1971	4,323,318	748,502	2,466,500	. .	. .	220,994
1972^p	4,151,000	860,481	1,615,700	. .	. .	. .

Source: Statistics Canada.
[1] Production from domestic ores, cobalt content. From 1967, production includes cobalt content of Inco and of Falconbridge shipments to overseas refineries, but prior years exclude Inco shipments to Britain. [2] Gross weight. [3]Consumption of cobalt in metal, oxides and salts.
^{p} Preliminary; . . Not available.

In the *Zaïre Republic*, Générale Congolaise des Mines (GECOMINES) has scheduled a five-year expansion program; the program called for an output of 16,000 short tons of cobalt annually by 1974. Zaïrian cobalt production is expected to be raised to 19,250 short tons a year by 1980. In *Zambia* a substantial increase in output of byproduct cobalt is expected from the Baluba copper mine, which commences production in 1973. The project is operated by the government-controlled mining company, Roan Consolidated Mines Limited.

The Greenvale project in Queensland, *Australia*, is scheduled to begin production of nickel and byproduct cobalt from laterite ore toward the end of 1974. Plant throughput is projected at 2.5 million pounds of cobalt a year in the form of nickel-cobalt sulphide concentrate (precipitate). The ore will be treated by an ammonia leaching process that was used by Freeport Minerals Company at Nicaro in Cuba. The Greenvale operation is a joint venture of Freeport Queensland Nickel, Inc. and Metals Exploration Queensland Pty., Ltd. Nippon Mining Co. in Japan has agreed to purchase all the nickel-cobalt sulphide output.

Cobalt will be produced in nickel matte starting early in 1973, by Western Mining Corporation Limited at its new smelter at Kalgoorlie, Western Australia. Western Mining produces nickel-cobalt sulphide precipitate as a coproduct of its Kwinarra nickel refinery near Perth, Australia, which is shipped to Sherritt Gordon's refinery in Fort Saskatchewan, Alberta, for toll refining. Western Mining and Sherritt Gordon have entered into joint agreement to each purchase half of the expected 11,100 short tons of nickel concentrate to be produced annually at Poseidon Limited's Western Australian mining operation when it begins production in 1974. The concentrate will be converted to matte at Western Mining Corporation's nickel smelter at Kalgoorlie; some will be shipped to Fort Saskatchewan for refining.

In the *Philippines*, design and construction of Marinduque Mining and Industrial Corporation's Surigao nickel project continued to progress on schedule with start-up planned for the second half of 1974. The smelter-refinery project is being built on Nonoc Island for projected initial production capacity of 3.3 million pounds a year of cobalt contained in mixed sulphide concentrates (precipitates) from

Table 3. World mine production of cobalt, 1970-72

	1970	1971	1972^p
	(short tons of contained cobalt)		
Republic of Zaïre	15,386	15,400	16,500
Zambia	2,645	2,293	2,200
Canada	2,280	2,162	2,075
Cuba^e	1,700	1,700	1,800
U.S.S.R.^{e}	1,700	1,750	1,800
Finland	1,108	1,018	990
Morocco	732	1,446	1,200
Australia	268	321	168
West Germany	910	662	715
United States^e	162	154	149
Total	26,891	26,906	27,597

Sources: Cobalt Information Centre, Brussels, Belgium; U.S. Bureau of Mines *Mineral Yearbook* preprint for 1970-71; for Canada, Statistics Canada.
^{e} Estimated; ^{p} Preliminary.

Table 4. United States, consumption of cobalt by uses, 1970-71

	1970	1971
	(thousands of pounds cobalt content)	
Steel (ingots and castings)		
High-speed and tool	534	318
Stainless steel	114	50
Alloy (excl. stainless and tool)	136	197
Cutting and wear-resistant materials		
Cemented or sintered carbides	1,395	1,230
Other materials	981	470
Welding and hardfacing rods, materials	181	246
Magnetic alloys	2,374	2,278
Nonferrous alloys	2,871	2,515
Electrical materials	. .	
Chemical and ceramic uses		
Catalysts	402	474
Ground coat frit	129	137
Glass decolourizer	69	60
Pigments	155	146
Other	7	102
Miscellaneous and unspecified	1,403	1,532
Salts and driers: lacquers, varnishes, paints, inks, pigments, enamels, feeds, electroplating (estimate)	2,616	2,745
Total	13,367	12,500

Source: U.S. Bureau of Mines, *Mineral Yearbook, 1970* and preprint from *Mineral Yearbook, 1971*.
. . Not available.

laterite ore. The refinery will employ Sherritt Gordon Mines, Limited's laterite metallurgical process. The company has entered into agreement for the sale of its cobalt output over a period of 10 years.

In *Finland*, initial production from the new Vuonos mine of Outokumpu Oy:n, a state-controlled company, commenced early in 1972. Cobalt from the Vuonos mine will augment Finland's output, which, prior to 1972, was obtained entirely from cobalt-bearing concentrate produced at the Outokumpu Keretti mine.

In *Japan*, Nippon Mining Co. and Sumitomo Metal Mining Co. plan cobalt refinery production in 1974 or 1975; combined capacity will be 2,420 short tons and the refineries will be fed with nickel-cobalt sulphide precipitates from Australia and the Philippines. The Sumitomo refinery will refine cobalt material from the Marinduque mining operation in the Philippines.

Consumption and uses

Cobalt consumption in Canada in 1971 was 220,994 pounds, of which 57.5 per cent was metal, 25.8 per cent was in the form of salts and 16.7 per cent was oxide.

United States is the largest consumer of cobalt. Domestic production of cobalt in pyrite concentrates as a byproduct of iron ore mining was discontinued at the end of 1971. Consumption of cobalt increased about 4 per cent in 1972 from 12.5 million pounds the previous year. Imports increased significantly in 1972 and were nearly equal to the 12.4 million pounds imported in 1970; 10.9 million pounds were imported in 1971. Cobalt in 1972 was supplied to users and processors in the form of metal (71.8 per cent), salts and driers (22.1 per cent), oxide (5.6 per cent) and other unspecified forms including scrap (0.5 per cent). United States consumption of cobalt increased from 8.9 million pounds in 1960 to 12.5 million pounds in 1971, equivalent to an annual growth rate of nearly 3 per cent.

The general pattern of consumption of cobalt by uses in the United States has not altered greatly during 1969-71. However, the proportion of cobalt consumed in magnet alloys has declined from 25.6-30.2 per cent during 1959-61 to 16.6-18.2 per cent during 1969-71. In Japan, on the other hand, magnet alloys have been estimated to account for about 80 per cent of total cobalt consumption. Owing to changes in United States Bureau of Mines end-use categories it is difficult to assess the trend of consumption of cobalt in high-temperature, high-strength alloys. Salts and driers have increased in relative importance; they rose from 10.8-13.1 per cent of total U.S. consumption during 1959-61 to 16.7-21.9 per cent during 1969-71.

One of the most important applications of cobalt is in high-temperature cobalt-base alloys used in such parts as nozzle guide vanes and turbine rotor blades in jet and turbine engines. Cobalt-base superalloys have seen their potential in the field of industrial and marine gas turbines increase as a result of the development of high-chromium compositions with improved oxidation and corrosion resistance. Consumption in the superalloys area is heavily dependent upon aerospace industry developments. Cobalt is used in a wide variety of magnetic materials in electrical and electronic applications. The principal types of cobalt-containing magnet materials include magnet steels; the Alnico alloys containing aluminum, nickel and cobalt; the magnetic iron oxides called 'ferrites'; and the maximum energy cobalt-rare earth alloys. The newly developed samarian-cobalt permanent high-energy magnets contain 60 to 70 per cent cobalt. Cobalt is also used in high-strength steels, hot-working and high-speed tool steels, cemented carbides and cobalt-chromium-tungsten hard-facing alloys. Among the nonmetallic uses, cobalt is used in ground-coat frits and in the sheet-enameling industry, in pigments for glass and ceramics, driers in paints, varnishes and printing inks, catalysts in various chemical processes and in feed supplements for cattle.

Prices

Published producer prices remained firm during 1972, following a price increase by African Metals Corporation, the supplier of Belgian refined cobalt from Zaïre, from U.S.$2.20 to $2.45 a pound effective December 27, 1971. Other producers raised their prices by similar amounts. On December 20, 1971, Sherritt Gordon Mines, Limited raised the price of its high-purity 'S' grade powder in 10-ton lots, 20 cents to $2.55 per pound of cobalt and briquettes were raised 20 cents to $2.58 a pound. Falconbridge raised the price of its electrolytic cobalt to U.S.$2.45 a pound on February 3, 1972, where it remained throughout the year. Sherritt announced a 15-cent price hike near year-end to increase 'S' grade cobalt powder to $2.70 a pound and cobalt briquettes to $2.73 a pound, same basis, effective January 2, 1973.

Prices of cobalt in U.S. currency:

	Nov. 17 1969	Dec. 27 1971	Dec. 1972
	(U.S.$)	(U.S.$)	(U.S.$)
Cobalt metal, per lb fob New York, Chicago			
Shot 99%+			
less than 50 kg	2.30	2.55	2.55
50-kg drums	2.25	2.50	2.50
250-kg	2.20	2.45	2.45
Powder, 99%+, 300-mesh			
50-kg drums	2.91	3.24	3.24
extra fine, 125-kg drums	3.49	3.89	3.89
Fines, 95-96% per lb contained Co			
regular, 500 lb	2.76	..	..
300-mesh	2.78	..	..
Briquettes, 10-ton lots, per lb contained	2.38	2.58	2.58
Cobalt oxide, per lb, 250 lb			
Ceramic, delivered, 5¢ more west of Mississippi			
70-71%	2.20	..	..
72½-73½%	2.26	..	..
Metallurgical, fob N.Y., 75-76%, per lb contained	2.85	..	..

Source: *Engineering Mining Journal*, December 1971 and 1972. *Metals Week*.

.. Not available.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
33200-1	Cobalt ore	free	free	free
35103-1	Cobalt metal, excluding alloys, in lumps, powders, ingots or blocks	free	free	25
35110-1	Cobalt metal, in bars	free	10	25
92824-2	Cobalt oxides	free	10	20
92824-1	Cobalt hydroxides	10	15	25
	(from July 15, 1971 to January 31, 1973)	free	15	25

Tariffs (concl'd)

United States

Item No.				
601.18	Cobalt ore	free		
632.20	Cobalt metal, unwrought, waste and scrap	free		

		On and After January 1	
		1971	1972
		(%)	(%)
632.84	Cobalt metal alloys, unwrought	10.5	9
633.00	Cobalt metal, wrought	10.5	9
418.68	Cobalt compounds other than cobalt oxide and cobalt sulphate	7	6
426.24, 426.26	Cobalt salts	7	6
418.60, 418.62	Cobalt oxide and Cobalt sulphate	0.9¢ per lb	0.7¢ per lb

Sources: Canada – The Customs Tariff and Amendments, Department of National Revenue Customs and Excise Division, Ottawa. United States – Tariff Schedules of the United States Annotated (1972), TC Publication 452.

Columbium (Niobium), Tantalum and Cesium

D.D. BROWN and J.G. GEORGE

COLUMBIUM

Demand for columbium (niobium) improved progressively through 1972 and by year-end consumption in Canada and the United States had reached record levels. Improved columbium markets reflected recovery in world steel production following the impact of recession in the steel industry during the previous two years. In addition, the increased demand during 1972 indicated a sharp rise in columbium consumption in high-strength low-alloy (HSLA) steels, used largely as structural and pipeline steels. Demand for columbium offered by the United States government General Services Administration was strong. A total of 2.96 million pounds of columbium pentoxide (Cb_2O_5) contained in various materials was sold during the year. None was sold in the previous year. Published producer prices of pyrochlore concentrate and ferro-columbium increased as strength in demand stepped up during the year.

Outlook

Brazil is the world's leading producer of pyrochlore with current production substantially below installed capacity. Companhia Brasileira de Metalurgia e Mineração (CBMM) in Brazil is likely to maintain its dominance for many years since its Araxá columbium deposit is believed to be the largest and highest-grade deposit in the world. Reserves are reported at 300 million tons with mill feed ranging from 3 to 4.5 per cent Cb_2O_5. CBMM and St. Lawrence Columbium and Metals Corporation in Canada are in a position to expand their production capacities to meet increasing demand. The growth rate of columbium demand will depend largely upon the HSLA steel demand and specifications for structural steel and for pipe in oil and natural gas transmission pipeline. An indication of future demand is given by United States growth of columbium-tantalum* consumption from 1963 to 1971. U.S. consumption of columbium-tantalum steel increased at about 10 per cent a year and consumption of columbium-tantalum in alloy and carbon steels has grown at about 14 per cent a year. Columbium-bearing HSLA steels have a promising market in major oil and gas transmission pipelines projected in various parts of the world. Japanese HSLA steel production has increased tenfold in the past decade to 2.7 million tons in 1970 and its percentage of total rolled steel output increased from 1.3 per cent to 3.6 per cent during the same period. In Canada, columbium demand for HSLA steel could accelerate as natural gas pipelines are constructed in the far north. World columbium resources in Brazil, Canada and Africa are more than adequate to provide for requirements well into the future; no long-term supply problems are anticipated.

Canada, production and developments

St. Lawrence Columbium and Metals Corporation, with mine, mill and concentrator near Oka, Quebec, is Canada's only producer of columbium and has one of only two mines in the world that produce columbium in pyrochlore concentrates as a primary product; the other larger operation is near Araxá, Brazil. Canada's production (shipments) of columbium as Cb_2O_5 in concentrates in 1972 was 3,900,000 pounds of Cb_2O_5 valued at $4,000,000, compared with 2,332,663 pounds valued at $2,296,962 in 1971.

During the fiscal year ended September 1972, 589,147 tons of ore were treated at the Oka mill of St. Lawrence Columbium and Metals Corporation. The capacity of the mill and concentrator was increased to 2,200 tons of ore a day and a further increase to 3,000 tons a day was planned for completion by the end of 1974. During 1972, St. Lawrence installed equipment for a new concentration process that would substantially improve the recovery of Cb_2O_5 at the Oka concentrator. The company also initiated an integration program that will result in a greater part of mine output being processed to ferrocolumbium.

The company reported that proven reserves on the St. Lawrence property at the end of 1972 consisted of 5.1 million tons averaging 0.483 per cent Cb_2O_5. Reserves on the adjoining property of Main Oka Mining Corporation that is held under lease by St. Lawrence are accessible for mining from the St. Lawrence underground workings. They are estimated at 1.9 million tons averaging 0.46 per cent Cb_2O_5.

Copperfields Mining Corporation Limited and Quebec Mining Exploration Company (SOQUEM) continued development of the St-Honoré columbium pyrochlore deposit some 7 miles north of Chicoutimi, Quebec. The company reported that pilot plant testing of bulk samples, completed during 1972 by the Department of Mines, indicated that the quality of columbium oxide concentrates produced is at least equal to that of existing producers. A feasibility study, including mine planning and plant design is in prepara-

*Includes ferrocolumbium, ferrocolumbium-tantalum, and other columbium-tantalum additives.

Table 1. Canada, columbium (niobium) and tantalum production, trade and consumption, 1971-72

	1971		1972[p]	
	(pounds)	($)	(pounds)	($)
Production				
Columbium (Cb_2O_5 content of shipments)	2,332,663	2,296,962	3,900,000	4,000,000
Tantalum (Ta_2O_5 content of shipments)	449,610	2,901,293	325,000	2,307,000
Imports[1] from United States				
Columbium and columbium alloys wrought	5,061	246,560	1,633[3]	49,346[3]
Tantalum and tantalum alloys wrought, nes	1,487	91,192	1,028	67,866
Tantalum and tantalum alloys, unwrought waste and scrap	14,237	32,296	3,175[3]	24,730[3]
Tantalum and tantalum alloy powder	3,100	97,220	545[3]	20,428[3]
Exports[2] to United States				
Columbium ore and concentrates	341,237	266,704	65,113	52,030
Consumption by the steel industry				
Ferrocolumbium and ferrotantalum-columbium (Cb and Ta-Cb content)	590,000	..	..	..

Source: Statistics Canada, except otherwise noted.
[1] From U.S. Department of Commerce, Export of Domestic and Foreign Merchandise, Report FT410. Values in U.S. currency. [2] From U.S. Department of Commerce, Imports of Merchandise for Consumption, Report FT 135. Values in U.S. currency. [3] First ten months.
[p] Preliminary; .. Not available.

Table 2. Canada, columbium (niobium) and tantalum production, trade and consumption, 1962-72

	Production[1]		Imports[2], from U.S.					
	Cb_2O_5 Content	Ta_2O_5 Content	Columbium and Alloys, Wrought	Tantalum and Alloys, Wrought	Tantalum and Alloys, Unwrought, Waste and Scrap	Tantalum and Alloys, Powder	Exports[3], Columbium Ores and Conc., to U.S.	Consumption, Ferrocol. and Ferrotantalum-Columbium, Cb and Ta-Cb Content
	(pounds)							
1962	1,016,514	–	–	–	–	–	1,509,928	26,000
1963	1,393,444	–	–	–	–	–	823,202	34,000
1964	2,163,359	–	–	–	–	–	1,940,133	74,000
1965	2,333,967	–	–	721	–	–	1,860,631	58,000
1966	2,637,997	–	–	1,533	–	2,730	1,524,279	40,000
1967	2,159,557	–	185	1,245	34,914	1,155	890,884	78,000
1968	2,181,304	–	375	1,972	3,433	1,830	295,333	288,000
1969	3,414,495	130,298	1,178	1,871	4,405	7,488	919,577	244,000
1970	4,694,239	317,024	–	854	1,870	2,480	1,270,362	292,000
1971	2,332,663	449,610	5,061	1,487	14,237	3,100	341,237	590,000
1972[p]	3,900,000	325,000	1,633[4]	1,028[4]	3,175[4]	545[4]	65,113	..

Source: Statistics Canada, unless otherwise noted.
[1] Producers' shipments of columbium and tantalum ores and concentrates and primary products, Cb_2O_5 and Ta_2O_5 content. [2] From U.S. Department of Commerce, Exports of Domestic and Foreign Merchandise, Report FT410. Quantities in gross weight of material. [3] From U.S. Department of Commerce, Imports of Merchandise for Consumption, Report FT135. Quantities in gross weight. [4] First 10 months.
[p] Preliminary; .. Not available; – Nil.

tion. On June 30, Copperfield's equity in the project was 44 per cent, which was being increased to 50 per cent. Ore reserves within the block drilled to a depth of 850 feet were calculated to be 40 million tons grading 0.76 per cent Cb_2O_5.

World production

In 1972, noncommunist world production of Cb_2O_5 contained in pyrochlore and columbite-tantalite mineral concentrates, excluding columbium contained in tin-smelter slags was an estimated 18.7 million pounds. About 91 per cent of columbium mine production was from pyrochlore concentrates containing 0.51 to 0.58 per cent Cb_2O_5 that was produced in Brazil (68 per cent) and Canada (23 per cent). The remainder of production was in the form of columbite-tantalite concentrates from Nigeria, Zaïre, Mozambique, Australia and Thailand. World production in 1971 was estimated at 11.6 million pounds of Cb_2O_5 in 21.8 million pounds of concentrate.

The largest producer of columbium since 1966 is the Companhia Brasileira de Metalurgia e Mineração (CBMM) at its open-pit columbium-pyrochlore mine near Araxá, Brazil. Reserves have been estimated at 300 million tons of ore grading 3 to 4.5 per cent Cb_2O_5. The company's production of columbium pentoxide increased from 1.4 million pounds of contained Cb_2O_5 in 1965 to 17 million pounds of contained Cb_2O_5 in pyrochlore concentrates in 1970. Mill capacity is presently 18,000 tons of concentrates a year or about 20 million pounds of Cb_2O_5 a year. In 1972 production was 12,547,000 pounds of Cb_2O_5.

In 1972, an arrangement was concluded between CBMM and a Brazilian state agency that provided for long-term joint operation of the columbium deposit held by CBMM, which is jointly owned by Brazilian interests (50.5 per cent), Molybdenum Corporation of America (33 per cent) and Pato Consolidated Gold Dredging, Limited.

United States

United States demand for columbium in steelmaking increased 22 per cent from 1971 to a new record high in 1972, as consumption of ferrocolumbium and other columbium and tantalum materials totalled 3.5 million pounds. Annual imports of columbium in concentrates based on nine months' data were 3.4 million pounds (gross weight) in 1972 compared with 3.054 million pounds in 1971. The principal suppliers of U.S. imports in 1972 were Brazil, 71 per cent (61% in

Table 3. Production of columbium (Cb) and tantalum (Ta) concentrates, 1969-71

	1969			1970			1971^p		
	Cb	Ta	Cb-Ta	Cb	Ta	Cb-Ta	Cb	Ta	Cb-Ta
	(thousands of pounds, gross)								
Brazil									
Pyrochlore	19,099	–	–	29,288	–	–	13,435	–	–
Columbite-tantalite	152	448	–	90	461	–	90^e	463^e	–
Canada									
Pyrochlore	6,829	–	–	9,838	–	–	4,560	–	–
Tantalite	–	246	–	–	594	–	–	845	–
Nigeria	3,340	13	–	3,563	10	–	3,040	9	–
Zaïre	–	–	384	–	–	322	–	–	251
Mozambique									
Columbite-tantalite	–	–	141	–	–	214	–	–	141^e
Microlite	–	181	–	–	140	–	–	120^e	–
Malaysia	–	–	141	–	–	134	–	–	54
Thailand	–	–	57	–	–	126	–	–	93
Portugal	–	13	–	–	9	–	–	24	–
Ruanda	–	–	49	–	–	. .	–	–	. . .
South Africa (Rep. of)	–	9	–	–	7	–	–	2	–
Australia	–	–	341	–	–	122	–	–	107
Other countries[3]	–	. .	8	–	–	16	–	–	27^e
Totals	29,420	910	1,121	42,779	1,221	934	21,125	1,463	673

Source: U.S. Bureau of Mines *Minerals Yearbook 1971* Preprint.
[1]Excludes tin slag bearing columbium-tantalum. [2]Concentrates containing important amounts of both elements are shown under Cb-Ta when composition data is insufficient. [3]Other countries that produce columbium and/or tantalum minerals include: Argentina, Ivory Coast, Uganda.
^{p}Preliminary; – Nil; . . Not available; . . . Less than one thousand pounds; ^{e}Estimate.

1971); Canada, 11 per cent (12% in 1971); and Nigeria, 22 per cent (16% in 1971). Consumption of ferrocolumbium (FeCb), ferrotantalum-columbium (FeTa-Cb) and other Cb-Ta materials in 1972 was 23 per cent above the previous year's consumption of 2.88 million pounds (Cb and Ta content). End-use consumption in 1972 and 1971 (in brackets) was as follows: alloy steels, 38 (27) per cent; carbon steels, 25 (29) per cent; stainless and heat-resisting steels, 18 (20) per cent; and superalloys, 16 (21) per cent. In 1971 the quantity of columbium and tantalum consumed in steelmaking was 2.2 million pounds and accounted for 76 per cent of all FeCb, FeTa-Cb and other Cb and Ta materials consumed. Columbium consumed in the form of high-purity metal during 1971 totalled 458,986 pounds, an increase of 76 per cent from consumption in 1970.

In 1972 the United States government General Services Administration (GSA) sold 1,705,320 pounds of columbium contained in combined columbium and tantalum concentrates, ferrocolumbium and columbium oxide powder. The GSA offers 1.5 million pounds of combined Cb_2O_5 and Ta_2O_5 during each fiscal year. At December 31, 1971, the government stockpile contained 7,757,000 pounds of columbium in concentrate.

Uses

Ferrocolumbium and ferrocolumbium-tantalum are used as addition agents in the production of specialty and alloy steels, with high-strength low-alloy (HSLA) steels being of greatest importance. HSLA steels currently contain less than 0.1 per cent carbon, 0.03 to 0.07 per cent columbium and have tensile strengths in the range of 60,000 to 70,000 psi. The reasons for the addition of columbium to low-carbon manganese HSLA steels are to control and refine grain size, increase tensile strength and improve impact properties. Columbium retards the recrystallization and grain growth of the austenite phase and enhances the nucleation rate of the ferrite phase to result in an increase in yield strength of steel. Columbium is usually used in combination with elements such as molybdenum, vanadium, and cerium. Arctic grade X-65 HSLA steel, currently used in Canadian natural gas pipeline, contains about 0.06 per cent columbium and 0.042 per cent carbon. The steel has excellent weldability, toughness below $0^\circ F$ and tensile strength above 65,000 psi. HSLA steel with high strength-to-weight ratio due to columbium and other additive elements are used in storage tanks, bridges, ships and high-rise buildings. Columbium is used in chromium-nickel stainless steels as a grain refiner to provide better corrosion resistance, higher strength, improved weldability and high-temperature creep resistance.

Columbium metal is used in superalloys in high-temperature applications such as in jet engines, turbine and rocket engine parts, and in nuclear reactors. Columbium metal could find increased usage in cryogenic applications such as the development of electrical motors and generators with superconducting windings and the development of cryogenic electric power transmission cable.

Canadian occurrences

The major source of columbium supply is from columbium-bearing pyrochlore from carbonatite-rock complexes in Canada and Brazil. In addition, columbite and tantalite are mined as coproducts of tin production, notably in Nigeria where concentrates containing 65 per cent or more of the combined oxides of columbium and tantalum are recovered.

Canadian deposits of columbium minerals in carbonate rocks known as carbonatites include:

– in *Quebec*, near Oka, the columbium-pyrochlore producing mine of St. Lawrence Columbium and Metals Corporation, the property of Columbium Mining Products Ltd., the property of Main Oka Mining Corporation, and the property of Quebec Columbium Limited; and the St-Honoré deposits of Quebec Mining Exploration Company (SOQUEM) and Copperfields Mining Corporation Limited near Chicoutimi;

– in *Ontario*, the James Bay property of Imperial Oil Enterprises Ltd. and Consolidated Morrison Explorations Limited and associated companies; the Manitou Island deposit of Nova Beaucage Mines Limited near North Bay; the Lackner Lake property of Multi-Minierals Limited near Chapleau; and the Nemegosenda Lake property of Dominion Gulf Company near Chapleau.

There are 30 or more known carbonatite occurrences in Ontario, several in Quebec, and several in British Columbia.

Prices

Published U.S. prices for pyrochlore and columbite increased through the year. Contract rates for standard-grade Canadian pyrochlore, fob mine and mill, moved from \$0.95 a pound of Cb_2O_5 to \$1.12 a pound in March and to \$1.39 a pound in October where it remained to year-end. Brazilian pyrochlore prices moved similarly from \$1.15 a pound of Cb_2O_5 at the beginning of the year to \$1.37 a pound of Cb_2O_5 in October. Columbite ore, cif U.S. ports, increased from \$0.75-\$0.85 a pound of contained pentoxides for material having Cb_2O_5 and Ta_2O_5 ratio of 10 to 1, at the beginning of the year, to \$0.95-\$1.05 a pound at year-end.

TANTALUM

Tantalum was in adequate supply in 1972, since metal producers have maintained large inventories of tantalum concentrate. Demand for tantalum concentrate was weak but the market for tantalum metal staged a strong recovery following the impact of a depressed market in 1971 and reduced demand for tantalum in the electronics industry. Much of the increased consumption was drawn from metal producers' inventories.

Precise statistics on tantalum production and supply are difficult to obtain since tantalum is combined with columbiun in varying proportions in columbite and tantalite mineral concentrates from a number of sources and a considerable but unreported part of world supply is recovered from tin-smelter slags. An increase in the price of tantalite is expected in 1973 following a price decrease late in 1972. Indications are that growth in demand will be about 8 per cent a year in electronics usage and somewhat less in other areas of application.

Canada

Canada's shipments of tantalum as tantalum pentoxide (Ta_2O_5) in 1972 was 325,000 pounds valued at $2,307,000, compared with 449,610 pounds of Ta_2O_5 valued at $2,901,293 in 1971. Canada's only tantalum producer, Tantalum Mining Corporation of Canada Limited (Tanco) began its Bernic Lake, Manitoba, mine, mill and concentrator operation in 1969. Tanco is an operating subsidiary of Chemalloy Minerals Limited, Toronto, and is currently the world's largest single producer of tantalite concentrates with 1972 production of 326,043 pounds of tantalum pentoxide (Ta_2O_5) in 325.5 tons of concentrate. Production in 1971 was 355,880 pounds of Ta_2O_5 in 711,000 pounds of concentrate. The company supplied about 9 per cent of United States imports of tantalite concentrates (gross weight) in 1972 compared with 46 per cent in 1971. Tantalite shipments to the United States in 1971 represented 73.4 per cent of Tanco's concentrate production during that year. Tanco's shipments to the U.S. market were reduced in 1972 partly because some of its production was inventoried in anticipation of firmer market conditions with improved prices. Chemalloy reported estimated reserves at December 31, 1972 of 1,419,576 tons grading 0.224 per cent Ta_2O_5, of which 388,460 tons grading 0.230 per cent Ta_2O_5 were in pillars. During 1971 and 1972, diamond drilling at Bernic Lake located a new tantalum-bearing zone with diamond drill intersections indicating mineralized widths from 5 to 30 feet that contained over 2 pounds of Ta_2O_5 a ton.

World production, consumption and trade

The recently established Tantalum Information Centre in Brussels, Netherlands, reported that noncommunist world production of tantalum in concentrates was 1.4-1.6 million pounds during 1972. Noncommunist world consumption of tantalum in 1972 was probably in the range of 1.6 to 2.0 million pounds. The shortfall in supply was provided from stocks of metal producers. The United States accounts for over 60 per cent of world consumption.

United States

United States demand in 1971 was an estimated 1.0 million pounds of tantalum consisting of 511,000 pounds in mineral concentrates and 490,000 pounds in tin-smelter slags. During 1972, imports of tantalite concentrates, reported by the U.S. Bureau of Mines, Mineral Industry Surveys, were about 1.2 million pounds (gross weight) compared with 1.18 million pounds imported in 1971. The principal suppliers of tantalum concentrates to the United States in 1972 compared with 1971 (in brackets) were Brazil, 32 (13) per cent; Australia, 30 (5) per cent; and Canada, 9 (44) per cent. Tantalum-bearing tin slags were available for import from Zaïre, Nigeria, Thailand and Penang (Malaysia). Nigerian and Penang slags contain about 4 per cent Ta_2O_5, compared with 9 per cent Ta_2O_5 for slags from Zaïre and 12 per cent for slags from Thailand. Thailand produces an estimated 490,000 pounds of tantalum annually in tin-smelter slag and Zaïre produces about 100,000 pounds.

United States reported shipments of tantalum products contained 961,500 pounds of tantalum in 1971; consumption of tantalum metal including capacitor-grade powder was 648,656 pounds.

The United States government General Services Administration (GSA) sold approximately 487,000 pounds of tantalum contained in 3.55 million pounds of combined columbium and tantalum pentoxides of various grades during 1972. There were no sales of tantalum from government stockpile in 1971. The material was sold at the equivalent of $4.75 to $5.25 a pound of Ta_2O_5. At June 30, 1972, the government stockpile contained 3.87 million pounds of tantalum that was rated at 31 per cent above objective requirements of 2.95 million pounds of tantalum.

Japan

Tantalum demand in Japan increased 11 per cent in 1972 to 175,000 pounds. Over 45 per cent of Japan's total consumption in 1972 was in carbides for cutting tools; capacitors represented 30 to 35 per cent of consumption. Japan's consumption of tantalum powder was 156,158 pounds in 1972.

Uses

Over 90 per cent of tantalum usage is based on the following four physical characteristics: tantalum's high melting point (2,996°C ± 50°) for high-temperature parts and alloys; the outstanding dielectric (capacitance) properties of its anodic oxide film on the surface of Ta powder for capacitors; its extreme degree of immunity to corrosion or chemical attack for chemical equipment; and the high melting point and hardness of tantalum carbide in cemented carbides.

The United States tantalum metal industry has three principal markets with the largest, which represents about 50-60 per cent of total use, being in the manufacture of tantalum powder and wire for electronic capacitors. A further 20-25 per cent of total consumption is in superalloys and aerospace applications; about 15 per cent of consumption is in corrosion-resistant chemical equipment. Tantalum carbide, used in cemented carbide cutting tools and wear-resistant parts to increase shock resistance, accounts for the remainder of consumption. The area of greatest potential growth in consumption is the capacitor market, which is expanding its use in telecommunications, computer and industrial applications. The lowering in price of Ta-capacitors through the use of high surface-area powders has opened up the prospect of increased use in the consumer electronics market in such areas as colour television and radio. Increased demand for tantalum corrosion-resistant applications may be encouraged by new production techniques that clad thin-gauge tantalum metal to steel and structural materials by explosive and chemical bonding.

Prices

Published U.S. spot prices for tantalite, about 60 per cent combined columbium and tantalum pentoxides, a pound of Ta_2O_5, were \$6.25-\$6.75 at the beginning of the year and \$5.25-\$6 a pound from October 26 to year-end. Tanco maintained its price quotations at \$7 a pound of contained Ta_2O_5 for contract sale of concentrates.

United States prices in U.S. currency, quoted in *Metals Week* of December 22, 1972,
(1971 year-end prices are shown in brackets when differing)

	($)
Columbium ore	
Columbite, per lb pentoxide, nominal spot cif U.S. ports	1.10-1.15
Pyrochlore, per lb Cb_2O_5	
Canadian fob mine or mill, contract only	1.39 (1.15-1.20)
Brazilian, fob shipping point contract only	1.37 (1.15)
Ferrocolumbium per lb Cb, ton lots, fob shipping point	
Low-alloy, standard grades	2.80 (2.45-2.65)
High-purity grades (incl. Ni)	4.12-6.81

Columbium metal, per lb. 99.5-99.8% free alongside, U.S. shipping port

	Powder, roundel	Ingot
	($)	($)
Reactor	12-23	17.50-28
Metallurgical	11-22	16-27

Tantalum metal, per lb	
Powder, fob shipping point, depending on size of lot	38-50-47.00 (28.50-38.50
Sheet and rod, depending on grade	36-60

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900-1	Columbium and tantalum ores and concentrates	free	free	free
315120-1	Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, bars, rods, tubing or wire for use in Canadian manufacture (expires 31 Oct. 1973)	free	free	25
37506-1	Ferrocolumbium, ferrotantalum, ferrotantalum-columbium	free	5	5

United States

Item No.		Effective on and after January 1 1971	1972
		(%)	(%)
601.21	Columbium ores and concentrates	free	free
601.42	Tantalum ores and concentrates	free	free
628.15	Columbium metal, unwrought, waste and scrap (duty on waste and scrap suspended to June 3, 1973)	6	5
628.17	Columbium, unwrought alloys	9	7.5
628.20	Columbium metal, wrought	10.5	9
629.05	Tantalum metal, unwrought, waste and scrap (duty on waste and scrap suspended to June 3, 1973)	6	5
629.07	Tantalum, unwrought alloys	9	7.5
629.10	Tantalum metal, wrought	10.5	9

Sources: Canada – The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. United States – Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

CESIUM

Pure cesium is a soft, silvery white, ductile metal with a melting point of 28.7°C, a boiling point of 705°C and a density of 1.87 grams per cubic centimetre at 20°C. It is not radioactive. It is the eighth lightest metallic element but of the five naturally occurring alkali metals cesium is the most electropositive, has the highest density, highest vapour pressure, lowest boiling point and lowest ionization potential. Because of these properties cesium is used in preference to other alkali metals in such space-age applications as space-propulsion and energy conversion.

Cesium emits electrons when exposed to visible light, ultraviolet light or infrared light. Precautions must be taken in handling, transporting and storing cesium metal because in air or water it is very reactive chemically; and when exposed to a combination of air and water it reacts violently. It is an efficient scavenger for traces of oxygen in highly evacuated containers. It resembles potassium and rubidium in the metallic state and is similar in chemical behaviour to potassium and rubidium but oxidizes more readily than any of the other alkali metals.

Occurrences and recovery

Of the naturally occurring alkali metals, cesium is the least abundant. It is, however, widely distributed in the earth's crust and usually at low concentrations. It occurs in certain granites and granitic pegmatites, with granites having been estimated to contain an average of about 1 part per million of cesium. Greater concentrations of cesium are found in lepidolite, carnallite, beryl, leucite, spodumene, petolite and related minerals. Although commercial quantities of cesium have been obtained from both lepidolite and carnallite, the most important economic source of the metal is the rare mineral pollucite. Pollucite is usually found in complex, generally well-zoned pegmatite dykes that are rich in lithium minerals, especially lepidolite.

Pollucite, a mineral resembling quartz in lustre and transparency, is a cesium aluminum silicate with the theoretically pure mineral containing 45 per cent cesium oxide (Cs_2O). Naturally occurring pollucite usually contains from 6 per cent to 32 per cent Cs_2O.

The higher grade variety of pollucite has a specific gravity of 2.9 and a hardness of 6.5 on Mohs' scale. It is colourless to white, or greyish or pinkish white.

The largest known reserves of pollucite are: 50,000 short tons* in the Karibib area in the Territory of South-West Africa, 150,000 tons in the Bikita district of Southern Rhodesia, and 460,000 tons at the mine of Chemalloy Minerals Limited at Bernic Lake in southeastern Manitoba, Canada, about 100 miles northeast of Winnipeg. Mozambique also has pollucite deposits but the quantity and grade of the reserves are not known. A second Canadian occurrence is at the Valor property in Lacorne Township, northwestern Quebec, formerly owned by Massval Mines Limited.

The only known Canadian cesium-bearing deposit of economic importance is that of Chemalloy Minerals Limited at Bernic Lake. The property is operated by Tantalum Mining Corporation of Canada Limited which is 75 per cent owned by Chemalloy Minerals Limited; the remaining 25 per cent interest being held by the Manitoba Development Corporation (MDC)

*All tons are short tons of 2,000 pounds unless otherwise specified.

which is the investment agency of the Manitoba government. The pollucite unit consists of three sheet-like bodies, the largest of which ranges up to 45 feet in thickness and lies in the southeast quadrant of the pegmatite. A substantial portion of the lenticular unit is nearly pure pollucite. It is gently dipping and, in general, concordant with the overall attitude of the pegmatite in which it occurs. The pollucite ore zone is separate from the company's tantalum and lithium orebodies (although the latter two do contain low cesium values) which are contained in the same deposit. As of July 31, 1973 the company's cesium reserves consisted of 300,000 tons of pollucite averaging 23 per cent Cs_2O in the main zone and 160,000 tons averaging 5 per cent Cs_2O in the lower and western zones. The main zone is open to the south and could be extended by further drilling. In addition there are large areas of the pegmatite body containing quantities of pollucite averaging 1 to 3 pounds of Cs_2O per ton which have not yet been assessed for ore reserves. Also, deeper holes below the main pegmatite body have indicated a second sill approximately 100 feet below the main body which contains pollucite, tantalite and spodumene mineralization. The company proposes to carry out exploration work for pollucite in this lower pegmatite as well as in other areas of the mine during 1973.

At the Valor property in northwestern Quebec, masses of pollucite up to 5 feet in maximum exposed dimension are scattered through part of the lenticular core zone of a complex zoned dyke. The zone consists chiefly of quartz, cleavelandite and spodumene, with irregular masses and disseminations of lepidolite.

The pollucite content of ores naturally rich in pollucite has been upgraded experimentally with some success, but satisfactory methods to concentrate pollucite economically from low-tenor ores have not yet been developed. The United States Bureau of Mines has, however, developed experimentally a froth flotation process for concentrating pollucite ore. When applied to a low-grade cesium ore from the state of Maine grading about 8 per cent Cs_2O, the ore was upgraded to over 21 per cent Cs_2O with a cesium recovery of almost 87 per cent. Thermochemical and hydrometallurgical methods are used for the production of cesium salts and compounds from pollucite ore. Cesium metal can be produced by direct thermochemical reduction of pollucite ore under vacuum or in an atmosphere of an inert gas (argon or helium) or by thermochemical reduction of a cesium compound under vacuum. Cesium metal has also been produced on a laboratory scale by electrolysis but this method of recovery has not yet proved economically feasible.

Production and consumption

Little statistical data is available on the production and consumption of pollucite or cesium metal and compounds. Annual world mine production of pollucite ore was estimated at only 20 tons as recently as 1968. Since then an increasing demand has resulted in a significantly greater output of pollucite, and especially because of the beginning of production by Chemalloy Minerals Limited late in 1969. Up to the end of August 1973 pollucite shipments from Chemalloy's Bernic Lake property totalled some 1,000 tons with the grade averaging about 28 per cent Cs_2O. Most of this material, all in the form of crushed ore, was shipped to Russia; the remainder was exported to Britain, the United States, and West Germany. In June 1973 Chemalloy received an order from Japan for pollucite ore.

Up until about 1968 world consumption of cesium metal and compounds was probably less than 10 tons a year. In the past few years, however, there has been a major increase in consumption mainly because of the increasing quantities of cesium compounds used in experimental magnetohydrodynamic (MHD) electrical power generators.

Uses

At present there are no large-scale commercial uses for cesium. Most of the metal and its compounds are currently consumed in the developmental research of thermionic power conversion units, ion propulsion, and MHD electrical power generators. In MHD pilot plants, which make use of cesium's low ionization potential, a fuel (coal, oil or gas) is burned. The hot gas is seeded with an easily ionized element such as cesium or potassium in the form of carbonates to increase its conductivity. The gas is accelerated through a chamber surrounded by a strong magnetic field resulting in the generation of electricity which is drawn off through electrodes placed in the channel. Major increases in efficiency and cheaper power with little or no pollution (cesium carbonate when used as the 'seed' is said to scrub out the harmful sulphur oxides produced by the burning coal or char) can be expected from MHD generators. Cesium salts as well as the metal are possible additives for MHD applications which are still in the research and development phase. While alternative materials may be used in this process, present knowledge is that cesium compounds are the most efficient.

In thermionic converters the heat from nuclear reaction radiates to a surrounding metal which emits large masses of electrons. The electrons travel through a space filled with a gas such as cesium vapour to an anode which then has a potential with respect to the cathode and electricity can flow through a load.

In the ion propelled engine, or ion thrusters, vapourized cesium is ionized while passing through a heated porous plate. The cesium ions become positively charged and an electric field accelerates the positive ions to a velocity of some 300,000 miles per hour. The high-velocity ions are exhausted through a nozzle to develop thrust. In recent years ion engines have offered attractive propulsion systems for missions with useful payloads from an Earth orbit to distant planets.

Commercial applications for cesium include its use in photo-multiplier tubes, vacuum tubes, scintillation counters, magnetometers, infrared lamps, time and frequency standards, pharmaceuticals and as reagents in microanalysis. Another commercial outlet is in photoelectric cells, developed in the early 1930's, where the photoemissive properties of cesium are utilized. Cesium and many of its alloys are photoelectric. An alloy of cesium and silver is used in the emitron or 'electric eye' used in television. Other uses are in biological research, medicine and as a catalyst in chemical processes. Cesium bromide is used in the manufacture of optical crystals. Cesium fluoride is used as a fluorinating agent in organic syntheses and cesium hydroxide for electrolyte in alkaline-type storage batteries. The metal may also act as a scavenger of gases and other impurities in chemical processing and in both ferrous and nonferrous metallurgy. Rubidium can be substituted for cesium in some of its applications.

Outlook

So far, the market for cesium metal and compounds has been quite limited as its high cost and extreme reactivity restricts its use to applications where its unique properties are important. Its relatively high cost also encourages the substitution of other materials wherever possible. The greatest potential for sharply increased consumption of cesium appears to be in a technological breakthrough in the research and development of a power generating process using cesium.

Grades, specifications and prices

Cesium metal is usually marketed in two main grades: (a) Standard, with a minimum cesium content of 99.5 per cent and (b) High purity, with a minimum cesium content of 99.9 per cent. Cesium salts are also available and include: carbonate, bromide, chloride, fluoride, iodide, hydroxide, acetate, chromate, nitrate and sulphate. Cesium is also available in a series of oxides.

A recent nominal quotation for raw pollucite ore of good grade and quality is about 75¢ per pound of contained Cs_2O. Cesium salts sell for about \$25 to \$50 a pound depending on the type of salt, grade and quantity purchased. Cesium metal of 99+ per cent purity has been quoted at \$100 to \$375 a pound depending on the quantity purchased.

Copper

ROBERT J. SHANK

The production of recoverable copper from Canadian mines in 1972, as estimated by Statistics Canada, amounted to a record 801,690 tons*, an increase of 80,260 tons from 1971. The value of this production also increased from $760,016,078 in 1971 to an estimated $810,976,000 in 1972. There is some unexplained discrepancy between the production tonnage estimated for 1972 by Statistics Canada and the tonnage of copper contained in concentrates produced during the year as reported by the mines. Normally, production as reported by Statistics Canada is about 2 per cent below actual mine output because an allowance of this magnitude is made for smelter losses. For 1972, the difference is about 4½ per cent, or some 21,000 tons greater than normal. Much of this can be accounted for by the creation of new stocks of concentrates in the delivery system which were not designated as having been shipped, by four large copper mines in British Columbia that commenced operations in 1972. A reported shortage of railway cars late in 1972 might also have delayed some shipments of concentrates to domestic smelters. Canada, with about 10.5 per cent of total world output, was the third-largest producer of copper in the world after the United States and the U.S.S.R., according to preliminary statistics. Mine production in Canada is expected to grow by 15 per cent in 1973 and a further 6 per cent in 1974 which should consolidate Canada in third place in world standings.

Output of refined copper from the two domestic refineries increased by 20,283 tons in 1972 to 546,686 tons. This amounted to 88 per cent of year-end rated capacity as compared with the 96 per cent rate obtained in 1971, but the 1972 figure is misleading inasmuch as 70,000 tons of new refinery capacity came on stream during the year. Smelter and refinery output is expected to rise during 1973 and 1974 as new capacity now being installed becomes operative.

Producers' domestic shipments of refined copper rose slightly in 1972 by 7,853 tons to 228,906 tons. This reflects a steady domestic market for fabricated and semifabricated copper and copper alloy products, and a slight gain in foreign sales of some products.

Internationally, copper supply and demand were in relative balance during 1972. Stocks of refined copper in London Metal Exchange (LME) warehouses, which were 149,000 tons at the end of 1971, rose to record levels during 1972 and amounted to some 210,000 tons at year-end. It is believed that much of this increase occurred because European consumers allowed their stocks to run down.

World mine production in 1972 of 7.6 million tons was 8 per cent above 1971 production of 7.1 million tons. All the major copper-mining countries, except Japan, reported increased output. The decline in Japan was caused by the closing of uneconomic operations.

World production of refined copper in 1972 rose by 7.5 per cent to 8.7 million tons from 8.1 million tons in 1971. Increases were broadly based although Chilean output was significantly lower.

Consumption of refined copper increased by 7 per cent in 1972 to 8.5 million tons from 8.0 million tons. Again, the increases were broadly based and reflect the improved business activity in North America, Europe and Japan.

1973 is expected to be a good year for copper. Sufficient copper should be available to satisfy normal growth unless strikes or other difficulties cause major production interruptions. The demand for refined copper should be strong throughout the year as European and Japanese consumption expand in line with the rapid growth in demand experienced in the United States in 1972. On balance, it can be expected that stocks of refined copper will decline and prices should be firm.

In the latter part of 1972, members of the Japanese copper industry were sounding out the copper industry throughout the world for their reactions to some form of international arrangement on copper. There is reason to believe these proposals will receive serious consideration at both industry and government levels in the next few years.

*All tons are short tons of 2,000 pounds unless otherwise specified.

Table 1. Canada, copper production, trade and consumption, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Production[1]				
Ontario	302,370	317,527,865	288,231	291,563,000
British Columbia	140,310	148,130,684	247,855	250,730,000
Quebec	184,823	195,173,430	172,190	174,188,000
Manitoba	55,264	58,356,093	58,511	59,187,000
Saskatchewan	11,146	11,769,842	13,138	13,291,000
Newfoundland	13,980	14,762,654	10,621	10,744,000
New Brunswick	10,266	10,841,025	9,473	9,583,000
Yukon	2,566	2,709,695	1,069	1,081,000
Northwest Territories	689	727,595	602	609,000
Nova Scotia	16	17,194	–	–
Total	721,430	760,016,078	801,690	810,976,000
Refined	526,403		546,686	
Exports				
Copper in ores, concentrates and matte				
Japan	167,230	147,726,000	229,607	189,579,000
Norway	32,707	28,866,000	25,961	21,317,000
West Germany	3,182	2,328,000	20,703	14,388,000
United States	8,339	6,337,000	12,099	8,871,000
Greece	–	–	4,941	5,171,000
Britain	1,766	1,716,000	1,803	1,653,000
Spain	2,443	2,421,000	1,569	1,555,000
Other countries	9,339	6,739,000	1,315	752,000
Total	225,006	196,133,000	297,998	243,286,000
Copper in slag, skimmings and sludge				
United States	237	198,000	88	34,000
Spain	–	–	38	10,000
Britain	63	19,000	20	6,000
Total	300	217,000	146	50,000
Copper scrap (gross weight)				
United States	7,355	6,964,000	7,721	6,716,000
West Germany	3,317	2,993,000	3,185	2,756,000
Japan	946	810,000	3,007	2,423,000
Norway	18	16,000	2,514	2,062,000
Spain	2,695	2,416,000	1,607	953,000
South Korea	751	664,000	1,129	895,000
Belgium and Luxembourg	2,493	1,699,000	874	557,000
Italy	80	73,000	443	365,000
Britain	190	152,000	283	98,000
Other countries	777	599,000	214	147,000
Total	18,622	16,386,000	20,977	16,972,000
Brass and bronze scrap (gross weight)				
United States	9,101	6,124,000	11,141	7,712,000
Japan	2,916	2,063,000	3,865	2,647,000
Italy	603	426,000	1,345	854,000
Britain	295	184,000	331	211,000
West Germany	1,165	903,000	183	137,000
Spain	245	129,000	251	103,000
Belgium and Luxembourg	411	247,000	335	86,000
Other countries	207	143,000	144	94,000
Total	14,943	10,219,000	17,595	11,844,000

Table 1 (cont'd)

	1971		1972^p	
Exports (cont.)	(short tons)	($)	(short tons)	($)
Copper alloy scrap, nes (gross weight)				
United States	191	130,000	218	166,000
Japan	100	98,000	41	27,000
Belgium and Luxembourg	38	15,000	69	23,000
Spain	–	–	32	8,000
Sweden	20	17,000	10	3,000
Other countries	86	39,000	–	–
Total	435	299,000	370	227,000
Copper refinery shapes				
United States	118,297	120,994,000	133,800	132,349,000
Britain	110,610	110,695,000	118,698	116,689,000
West Germany	34,059	33,899,000	30,811	30,083,000
France	12,317	12,573,000	9,495	9,245,000
Belgium and Luxembourg	7,588	7,680,000	7,987	7,449,000
Italy	8,631	8,596,000	4,863	4,729,000
Sweden	4,237	4,164,000	4,521	4,365,000
Portugal	3,859	3,897,000	3,454	3,369,000
Greece	936	959,000	2,153	2,157,000
Switzerland	3,748	3,630,000	2,026	1,941,000
Spain	1,933	1,881,000	1,383	1,391,000
Brazil	3,515	3,430,000	1,311	1,225,000
India	2,842	2,772,000	1,288	1,225,000
Other countries	1,706	1,741,000	1,651	1,679,000
Total	314,278	316,911,000	323,441	317,896,000
Copper bars, rods and shapes, nes				
United States	1,739	2,619,000	2,513	3,353,000
Norway	3,595	3,668,000	2,939	2,877,000
Lebanon	1,129	1,173,000	2,315	2,277,000
Poland	1,432	1,525,000	1,983	2,082,000
Britain	855	903,000	1,971	2,076,000
Venezuela	795	880,000	1,532	1,540,000
Denmark	1,619	1,704,000	1,402	1,472,000
Switzerland	2,009	2,007,000	1,483	1,430,000
Dominican Republic	724	770,000	929	987,000
Other countries	5,075	5,261,000	2,127	2,116,000
Total	18,972	20,510,000	19,194	20,210,000
Copper plates, sheet, strip and flat products				
United States	7,009	10,172,000	7,673	10,695,000
Venezuela	256	392,000	274	429,000
Britain	66	101,000	271	414,000
Peru	19	34,000	50	72,000
New Zealand	57	82,000	26	39,000
Egypt	–	–	22	31,000
Greece	4	6,000	18	30,000
Other countries	45	67,000	6	8,000
Total	7,456	10,854,000	8,340	11,718,000
Copper pipe and tubing				
United States	7,136	8,010,000	10,699	12,423,000
Britain	335	466,000	1,084	1,528,000
New Zealand	395	734,000	528	938,000

Table 1 (cont'd)

	1971		1972[p]	
Exports (cont.)	(short tons)	($)	(short tons)	($)
Copper pipe and tubing (cont'd)				
Israel	442	567,000	509	668,000
Venezuela	157	267,000	282	529,000
Panama	161	220,000	198	280,000
Puerto Rico	85	123,000	165	245,000
Other countries	1,304	2,029,000	907	1,395,000
Total	10,015	12,416,000	14,372	18,006,000
Copper, wire and cable (not insulated)				
United States	181	259,000	185	250,000
Iran	37	46,000	143	160,000
Jamaica	120	149,000	132	160,000
Pakistan	45	52,000	45	57,000
Other countries	118	160,000	85	126,000
Total	501	666,000	590	753,000
Copper alloy refinery shapes				
United States	11,391	13,802,000	11,661	14,067,000
Venezuela	156	213,000	140	195,000
Peru	33	46,000	48	76,000
Puerto Rico	1	1,000	33	40,000
New Zealand	11	16,000	24	36,000
Belgium and Luxembourg	–	–	22	32,000
Greece	3	4,000	17	30,000
Other countries	686	627,000	70	79,000
Total	12,281	14,709,000	12,015	14,555,000
Copper alloy pipe and tubing				
United States	2,088	2,723,000	3,163	3,814,000
India	4	11,000	374	575,000
Puerto Rico	114	156,000	242	337,000
Taiwan	–	–	118	194,000
Britain	41	74,000	97	138,000
New Zealand	55	91,000	83	138,000
Israel	293	581,000	57	117,000
Other countries	234	473,000	213	273,000
Total	2,829	4,109,000	4,347	5,586,000
Copper alloy wire and cable, not insulated				
United States	105	199,000	81	168,000
Australia	2	8,000	11	44,000
Venezuela	2	14,000	26	35,000
New Zealand	–	–	2	4,000
Other countries	15	28,000	6	11,000
Total	124	249,000	126	262,000
Copper alloy fabricated materials, nes				
United States	587	868,000	1,133	1,490,000
Brazil	729	1,863,000	294	630,000
Britain	66	105,000	46	84,000
New Zealand	1	4,000	13	30,000
Australia	5	10,000	6	19,000
Other countries	79	117,000	62	119,000
Total	1,467	2,967,000	1,554	2,372,000

Table 1 (concl'd)

	1971		1972[p]	
Exports (cont.)	(short tons)	($)	(short tons)	($)
Wire and cable insulated[2]				
India	3,295	5,754,000	10,280	18,749,000
United States	8,635	18,090,000	8,074	12,073,000
Venezuela	146	261,000	639	1,312,000
Dominican Republic	529	860,000	600	1,082,000
Turkey	831	747,000	501	829,000
West Germany	206	266,000	538	615,000
Libya	120	171,000	240	333,000
Bermuda	271	388,000	172	243,000
South Africa	231	333,000	91	222,000
Israel	2	5,000	83	176,000
Panama	634	921,000	115	171,000
Britain	152	286,000	80	159,000
Other countries	3,316	4,695,000	1,549	2,247,000
Total	18,368	32,777,000	22,962	38,211,000
Total exports of copper and products		639,422,000		701,948,000
Imports				
Copper in ores, concentrates and scrap	21,645	16,030,000	17,776	11,725,000
Copper refinery shapes	21,899	22,369,000	17,840	18,010,000
Copper bars, rods and shapes, nes	487	551,000	347	402,000
Copper plates, sheet strip and flat products	619	1,060,000	630	1,016,000
Copper pipe and tubing	3,122	4,765,000	4,096	5,995,000
Copper wire and cable, except insulated	182	360,000	253	601,000
Copper alloy scrap (gross weight)	3,991	2,737,000	3,864	2,469,000
Copper powder	353	546,000	403	567,000
Copper alloy refinery shapes, rods and sections	7,475	8,006,000	10,036	10,463,000
Brass plates, sheet and flat products	3,864	4,648,000	4,140	4,680,000
Copper alloy plates, sheet, strip and flat products	915	1,736,000	613	1,478,000
Copper alloy pipe and tubing	1,492	2,620,000	1,699	2,990,000
Copper alloy wire and cable, except insulated	558	1,059,000	566	1,079,000
Copper alloy castings	262	526,000	281	543,000
Copper and alloy fabricated material, nes	995	1,599,000	2,243	3,252,000
Insulated wire and cable	..	11,670,000	..	16,018,000
Copper oxides and hydroxides	197	247,000	229	286,000
Copper sulphate	2,003	801,000	1,732	643,000
Total imports of copper and products	..	81,330,000	..	82,217,000
Consumption[3]				
Refined	221,053	..	228,906	..

Source: Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Includes also small quantities of non-copper wire and cable, insulated. [3] Producers' domestic shipments, refined copper.
[p] Preliminary; – Nil; .. Not available; nes Not elsewhere specified.

Table 2. Canada, copper production, trade and consumption, 1963-72

	Production		Exports				
	All Forms	Refined	Ore and Matte	Refined	Total	Imports, Refined	Consumption[2], Refined
			(short tons)				
1963	452,559	380,075	92,930	214,987	307,917	6,549	169,750
1964	486,900	407,942	104,550	224,273	328,823	6,771	202,225
1965	507,877	434,133	87,000	199,830	286,830	5,747	224,684
1966	506,076	433,004	94,888	190,691	285,579	10,492	262,557
1967	613,314	499,846	128,976	275,919	404,895	5,310	219,680
1968	633,313	524,474	161,835	276,619	438,454	5,824	250,104
1969	573,246	449,232	157,816	210,034	367,850	18,137	226,281
1970	672,717	543,727[r]	177,888[r]	292,403	470,291	14,542	237,916[r]
1971	721,430	526,403	225,006	314,728	539,734	21,899	221,053
1972[p]	801,690	546,686	297,998	323,441	621,439	17,840	228,906

Source: Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrates exported. [2] Producers' domestic shipments, refined copper.
[p] Preliminary; [r] Revised.

Canadian supply and demand

Mines. There was a major shift westward in copper mining capacity in 1972 as fourteen small-to-medium mines were closed, production at four others was suspended for marketing reasons, and fourteen new mines were opened, four of which were large open pit operations in British Columbia. During 1972, operating Canadian mines had an installed capability to produce an estimated 825,000 tons of recoverable copper annually under normal operating conditions. As the new capacity installed in 1972 becomes fully operative, this capability will rise to about 925,000 tons in 1973 and 985,000 tons in 1975. It is important to note the few new mines scheduled for production (Table 4). This probably reflects the low copper prices of 1971-72, a fear of excess production capacity in the world, short-term saturation of the Japanese market for copper concentrates, and a slowdown in exploration activity in Canada.

Strikes and labour difficulties caused minimal loss of production in 1972. A strike at Campbell Chibougamau Mines Ltd. lasted from December 18, 1971 to March 14, 1972, and Madeleine Mines Ltd. was struck from November 13, 1972 to year-end. A Japanese seamen's strike caused some delay in shipments of concentrates to Japan at midyear.

There were no serious problems arising from the actions of the Japanese smelters to curtail shipments of concentrates. No production cutbacks took place and most of the excess concentrates were marketed elsewhere, mainly in Europe.

Output of copper by The International Nickel Company of Canada, Limited (Inco) was down by about 9 per cent from 1971 compared with a reduction of 20 per cent in nickel production. This lower output reflects the operating cutbacks initiated by Inco in the latter half of 1971 because of larger than normal nickel stocks.

Only one new mine, the Ruttan mine of Sherritt Gordon Mines, Limited, is scheduled to start production in 1973. Four Inco mines are on standby while development of four mines owned by Falconbridge Nickel Mines Limited has been deferred.

Information pertaining to individual mines can be obtained from accompanying tables. Table 3 lists all mines that produced copper in 1971 and 1972, along with production statistics and a brief description of events. The statistics used have largely been obtained directly from each company. Table 4 lists the mines for which production plans have been announced. Table 5 lists some properties that are actively being explored and may become producers in the near future.

Table 3. Producing copper mines in Canada, 1972 and [1971]

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Grade of Ore: Zinc	Grade of Ore: Nickel	Grade of Ore: Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Newfoundland								
American Smelting and Refining Company, Buchans	1,250 [1,250]	1.13 [1.08]	12.89 [12.39]	– [–]	3.73 [3.71]	291,000 [173,000]	3,017 [1,698]	Operations interrupted by 5-month strike in 1971.
British Newfoundland Exploration Limited Whalesback mine, Springdale	– [2,000]	– [0.78]	– [–]	– [–]	– [–]	– [562,000]	– [3,890]	Operations suspended June 1972; ore reserves exhausted.
Consolidated Rambler Mines Limited, Ming and East mines, Baie Verte	1,200 [1,500]	1.84 [1.12]	– –	– –	0.35 [0.08]	386,205 [429,351]	6,933 [4,730]	Reduction in mill capacity due to harder and higher grade ore from Ming mine.
First Maritime Mining Corporation Limited, Gullbridge mine, Badger	– [2,500]	– [0.62]	– –	– –	– –	– [693,607]	– [4,012]	Operations closed Dec. 5, 1971 because copper prices declining.
Nova Scotia								
Dresser Minerals Division of Dresser Industries, Inc., Walton	[140]	– [0.36]	– [0.50]	– –	– –	– [16,125]	– [53]	Concentrator did not operate in 1972.
New Brunswick								
Anaconda Canada Limited, Caribou mine, Restigouche Co.	– [1,000]	– [3.83]	– [1.90]	– –	– ..	– [154,995]	– [2,706]	Operations suspended Nov. 1971 due to metallurgical difficulties in producing marketable concentrates.
Brunswick Mining and Smelting Corporation Limited, Bathurst								
No. 6 mine	3,500 [3,500]	0.37 [0.36]	5.46 [5.76]	– –	2.10 [1.86]	1,743,610 [1,300,946]	3,485 [1,967]	
No. 12 mine	6,350 [6,000]	0.27 [0.30]	9.10 [8.11]	– –	2.82 [2.44]	1,513,949 [1,567,352]	3,197 [2,648]	

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Copper	Grade of Ore Zinc	Grade of Ore Nickel	Grade of Ore Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Heath Steele Mines Limited, Newcastle	3,000 [3,000]	. . [0.97]	. . [5.29]	– –	. . [2.21]	835,867 [972,456]	6,297 [6,190]	Expanding production to 4,000 tpd by 1976.
Nigadoo River Mines Limited, Robertville	– [1,000]	– [0.27]	– [2.66]	– –	– [3.37]	– 322,956]	– [746]	Operations suspended indefinitely Jan. 4, 1972 following labour strike.
Quebec								
Campbell Chibougamau Mines Ltd. Cedar Bay, Henderson, Kokko Creek, and Main mines, Chibougamau	4,000 [4,000]	1.48 [1.52]	– –	– –	0.24 [0.27]	987,266 [1,294,285]	13,601 [17,957]	Production interrupted by strike from Dec. 18, 1971 to March 14, 1972.
Delbridge Mines Limited, Noranda	– [500]	– [0.45]	– [8.62]	– –	– [2.86]	– [154,172]	– [678]	Operations closed Sept. 2, 1971 as ore reserves exhausted.
Falconbridge Copper Limited, Lake Dufault Division, Norbec and Millenbach mines, Noranda	1,500 [1,500]	3.16 [1.48]	4.39 [2.02]	– –	1.40 [0.60]	561,625 [509,095]	16,425 [7,331]	Mining of Norbec ore to end in 1973 when ore reserves will be exhausted. A 1,700-foot winze being sunk at Millenbach mine.
Opemiska Division, Perry, Robitaille, and Springer mines, Chapais	3,000 [3,000]	2.20 [2.31]	– –	– –	0.33 [0.31]	1,156,864 [1.074,047]	24,048 [23,706]	Work to commence in 1973 for new Cooke mine. Production at Robitaille mine completed in 1972.
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain mines, Murdochville	11,000 [11,000]	0.91 [0.91]	– –	– –	0.15 . .	3,939,738 [3,980,525]	33,940 [32,717]	Mill capacity being expanded to 34,000 tpd by mid-1973. Will also vat leach 5,000 tpd of oxide ore commencing late 1973.
Icon Sullivan Joint Venture, Chibougamau	650 [650]	3.13 [2.95]	– –	– –	. . . .	208,471 [221,496]	6,378 [6,526]	
Joutel Copper Mines Limited, Joutel	700 [700]	1.90 [2.24]	– –	– –	– –	149,651 [239,201]	2,453 [4,988]	Ore trucked to Mines de Poirier mill. Mining of copper ore ceased August 1972. Mining of remaining zinc ore to be completed in 1973.

Louvem Mining Company Inc., Louvicourt	850 [800]	1.51 [2.13]	– –	– –	0.24 [0.34]	272,736 [279,502]	3,896 [5,724]	Ore trucked to Manitou-Barvue mill. Exploration of ore zone continuing. Mining converted from open pit to underground.
Madeleine Mines Ltd., Gaspé Provincial Park	2,500 [2,500]	1.42 [1.38]	– –	– –	0.30 ..	729,608 [869,467]	9,688 [11,246]	Mine closed by strike from Nov. 13, 1972 to year-end.
Manitou-Barvue Mines Limited, Val-d'Or	1,600 [1,600]	– ..	1.16 [1.96]	– –	4.68 [4.42]	60.234 [225,915]	– [52]	
Mattagami Lake Mines Limited, Matagami	3,850 [3,850]	0.56 [0.62]	7.40 [9.30]	– –	0.88 [1.07]	1,370,167 [1,386,160]	6,270 [7,232]	
Noranda Mines Limited, Horne Division,	3,000 [3,000]	2.30 [2.24]	– –	– –	0.49 [0.43]	686,566 [682,618]	14,604 [14,667]	Ore reserves expected to be exhausted by mid-1974.
Normetal Mines Limited, Normetal	1,000 [1,000]	1.73 [1.76]	5.29 [5.74]	– –	1.43 [1.50]	326,475 [335,298]	5,256 [5,534]	Ore reserves expected to be exhausted by early 1974.
Orchan Mines Limited, Orchan and Garon Lake mines, Matagami	2,000 [2,000]	1.05 [0.93]	10.60 [10.66]	– –	1.10 [1.27]	376,840 [409,492]	3,243 [3,136]	Trucking ore from Garon L. mine to Orchan mill commenced late in 1972.
Patino Mines (Quebec) Limited, Copper Rand, Copper Cliff, Jaculet, and Portage mines, Chibougamau	2,800 [2,800]	1.77 [1.94]	– –	– –	0.19 [0.21]	1,018,633 [992,401]	17,352 [18,472]	
Quemont Mines Limited, Noranda	– [2,400]	– [0.78]	– [2.06]	– –	– [1.03]	– [332,916]	– [2,361]	Operations closed Nov. 11, 1971 as ore reserves exhausted.
Renzy Mines Limited, Hainault Township	.. [1,000]	.. [0.55]	– –	.. [0.43]	– –	.. [314,630]	.. [1,437]	Operations suspended April 1972 pending negotiation of new smelter contract.
Rio Algom Mines Limited, Mines de Poirier mine, Joutel	1,800 [2,500]	2.22 [2.61]	– –	– –	– –	651,713 [613,603]	13,438 [15,095]	
Sullivan Mining Group Ltd., Cupra and D'Estrie Divisions, Stratford Centre	1,500 [1,400]	2.46 [2.22]	3.64 [3.35]	– –	1.10 [1.02]	226,477 [218,169]	5,370 [4,409]	
Weedon Mines Division, Stratford Centre		1.82 [1.44]	0.76 [0.85]	– –	0.35 [0.32]	177,248 [181,037]	3,074 [2,422]	Mine to be closed in 1973.

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)		(tons)	(tons)	
Ontario								
Canadian Jamieson Mines Limited, Timmins	– [550]	– [1.33]	– [2.14]	– –	– –	– [20,567]	– [248]	Operations ceased Feb. 12, 1971 as ore reserves exhausted.
Consolidated Canadian Faraday Limited, Werner Lake	1,200 [1,100]	0.37 [0.35]	– –	0.78 [0.83]	– –	56,696 [99,731]	187 [307]	Mining ceased Aug. 1972 due to exhaustion of ore reserves. Milling of Dumbarton ore continuing.
Copperfields Mining Corporation Limited, Timagami	200 [200]	4.85 [5.88]	– –	– –	. . [0.36]	6,343 [53,108]	307 [3,061]	Operations closed Feb. 29, 1972. Ore reserves exhausted.
Ecstall Mining Limited, Kidd Creek mine, Timmins	10,000 [10,000]	1.44 [1.38]	10.14 [9.74]	– –	4.35 [4.05]	3,628,501 [3,673,350]	47,915 [46,520]	Tin concentrates to be produced commencing late in 1973.
Falconbridge Nickel Mines Limited East, Falconbridge, Fecunis, Hardy-Boundary, Longvack South, North, Onaping, and Strathcona mines, Falconbridge	3,000 (Falconbridge) 2,500 (Fecunis) 1,500 (Hardy) 6,600 (Strathcona)	. . . .	– –	. . . .	. . . .	4,152,185 [4,703,000]	28,232[d] [30,492][d]	Open pit mining of Hardy crown pillar started. Hardy mill closed because of high costs.
The International Nickel Company of Canada, Limited Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Little Stobie and Maclennan mines, Sudbury Shebandowan mine, Shebandowan	35,000 (Clarabelle) 24,000 (Frood-Stobie) 11,400 (Creighton) 6,200 (Levack) 2,500 (Shebandowan)	. . . .	– –	. . . .	. . . .	15,894,577 [21,847,700]	154,100[d] [170,150][d]	Production from Shebandowan mine commenced in 1972; mining at Maclennan mine was completed. Average grade of ore mined in Ontario and Manitoba in 1972 was 0.91% copper and 1.33% nickel compared with 0.74% copper and 1.12% nickel in 1971. Crean Hill, Totten and Murray mines placed on standby.

Jameland Mines Limited, Timmins	700 [700]	0.94 [1.29]	3.59 [1.95]	– –	– –	138,029 [156,586]	989 [1,634]	Operations terminated Dec. 20, 1972.
Kam-Kotia Mines Limited, Timmins	2,700 [2,500]	0.73 [0.78]	2.38 [2.51]	– –	– –	422,399 [480,145]	2,434 [3,047]	Operations terminated Dec. 30, 1972.
Mattabi Mines Limited, Sturgeon Lake	3,000 –	1.27 –	11.97 –	– –	4.99 –	438,838 –	4,281 –	Production started July 1972.
McIntyre Porcupine Mines Limited, Schumacher	2,100 [2,200]	0.65 [0.67]	– –	– –	0.11 [0.11]	758,380 [773,250]	4,621 [4,826]	
Noranda Mines Limited, Geco Division, Manitouwadge	5,200 [5,000]	2.12 [2.27]	4.30 [5.52]	– –	1.93 [2.03]	1,815,164 [1,759,952]	35,985 [37,656]	
North Canadian Enterprises Limited, Coppercorp mine, Port Mamainse	500 [500]	. . [1.26]	– –	– –	– –	59,644 [156,111]	. . [1,903]	Operations ceased Nov. 30, 1972.
Selco Mining Corporation Limited, South Bay Division, Uchi Lake	500 [500]	2.10 [2.33]	12.00 [13.29]	– –	3.20 . .	183,000 [130,019]	3,561 [2,766]	
Tribag Mining Co., Limited, Batchawana Bay	500 [500]	1.26 [1.47]	– –	– –	. . . .	190,949 [191,725]	2,323 [2,722]	
Upper Beaver Mines Limited, Dobie	300 [300]	1.94 [1.45]	– –	– –	. . . .	6,268 [88,390]	115 [1,280]	Production ceased Jan. 21, 1972.
Willroy Mines Limited, Manitouwadge	1,700 [1,600]	1.10 [0.89]	3.27 [3.33]	– –	1.41 [1.36]	431,067 [427,589]	4,380 [3,511]	
Manitoba								
Dumbarton Mines Limited, Bird River	1,100 [800]	0.28 [0.32]	– –	0.86 [0.86]	– –	325,766 [299,480]	831 [867]	Ore trucked to Faraday mill.
Falconbridge Nickel Mines Limited, Manibridge mine, Wabowden	1,000 [1,000]	. . . .	– –	. . . .	. . . .	166,399 . .	. . . .	

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Hudson Bay Mining and Smelting Co., Limited, Anderson, Chisel, Dickstone, Flin Flon, Ghost, Osborne, Schist, Stall, and White Lake mines, Flin Flon and Snow Lake	6,800 [7,500]	2.67 [2.80]	3.28 [3.20]	– –	0.59 [0.50]	1,847,903 [1,084,000]	47,472 [28,917]	Plants shut by 5-month strike in 1971. Includes Saskatchewan production. Ghost L. mine started production Aug. 21, 1972 and White L. mine June 15, 1972. Mill capacity being increased by 15%.
The International Nickel Company of Canada, Limited Birchtree, Pipe and Thompson mines, Thompson	18,400 [18,400]	. . . .	– –	. . . .	– –	3,043,648 [4,776,678]	154,100[d] [170,150][d]	See Ontario. Soab mine placed on standby.
Sherritt Gordon Mines, Limited, Lynn Lake mine, Lynn Lake	3,500 [3,500]	0.38 [0.41]	– –	0.67 [0.66]	– –	995,000 [1,158,000]	3,171 [4,055]	
Fox Lake mine, Lynn Lake	3,000 [3,000]	2.14 [2.86]	1.40 [1.54]	– –	– –	946,000 [1,022,000]	18,128 [27,519]	
Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flexar and Flin Flon mines, Flin Flon			see Manitoba					Flexar mine closed; ore reserves exhausted.
Rio Algom Mines Limited, Anglo-Rouyn mine, La Ronge	750 [900]	1.86 [1.52]	– –	– –	. . [0.19]	182,146 [309,489]	3,263 [4,246]	Operations closed Aug. 1972. Ore reserves depleted.
British Columbia								
Alwin Mining Company Ltd., O.K. mine, Highland Valley	500 –	. . –	– –	– –	. . –	. . –	1,966 –	Production started Feb. 1972, suspended Dec. 7, 1972 because operation uneconomic.
Anaconda Canada Limited, Britannia mine, Britannia Beach	3,000 [3,000]	1.38 [1.17]	– –	– –	0.27 . .	765,517 [720,964]	9,990 [7,962]	

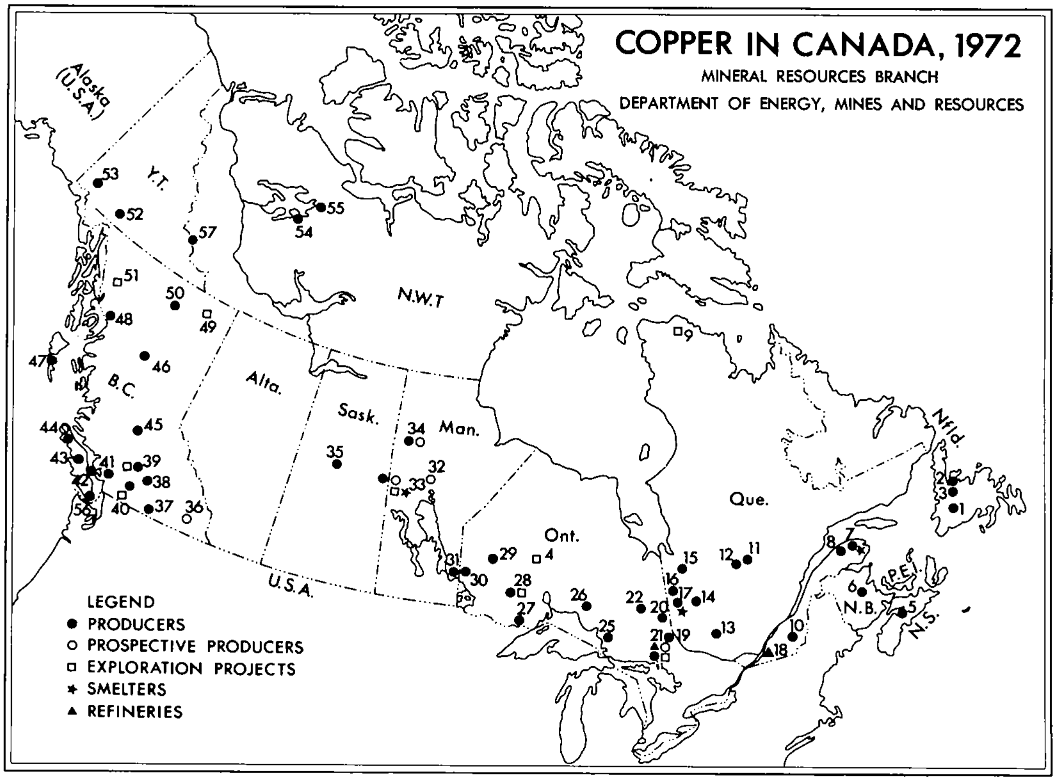
Bethlehem Copper Corporation Ltd., Heustis and Jersey mines, Highland Valley	16,300 [15,000]	0.54 [0.52]	– –	– –	– –	5,964,696 [5,625,999]	29,111 [25,350]	
Bradina Joint Venture, Houston	600 –	0.42 –	4.45 –	– –	5.31 –	111,024 –	364 –	Milling commenced Mar. 9, 1972.
Brenda Mines Ltd., Peachland	24,000 [24,000]	0.21 [0.21]	– –	– –	– –	9,503,190 [8,987,210]	17,846 [17,082]	
Churchill Copper Corporation Ltd., Magnum mine, Fort Nelson	– [750]	– [3.32]	– –	– –	– –	– [177,096]	– [5,905]	Operations suspended Oct. 1, 1971 because copper prices low.
Cominco Ltd., Coast Copper mine, Benson Lake, V.I.	750 [750]	. . [1.97]	– –	– –	– –	225,761 [295,684]	4,066 [5,533]	Operations suspended Nov. 30, 1972 due to rising costs and depressed copper market.
Craigmont Mines Limited, Merritt	5,000 [5,000]	1.36 [1.15]	– –	– –	– –	1,894,260 [1,827,864]	24,275 [19,661]	
Falconbridge Nickel Mines Limited, Wesfrob mine, Tasu Harbour, Q.C.I.	8,000 [8,000]	0.47 [0.70]	– –	– –	– –	595,505 [996,471]	2,705 [6,797]	Operations suspended from July 8 to Aug. 21, 1972 because of Japanese seamen's strike.
Giant Mascot Mines Limited, Hope	1,875 [1,750]	0.38 [0.39]	– –	0.68 [0.77]	– –	389,894 [260,241]	1,353 [983]	
Gibraltar Mines Ltd., McLeese Lake, Cariboo District	38,000 –	0.45 –	– –	– –	– –	11,243,221 –	41,025 –	Milling commenced officially April 1, 1972.
The Granby Mining Company Limited, Granisle mine, Babine Lake	14,000 [6,500]	0.55 [0.56]	– –	– –	– –	2,537,138 [2,288,952]	12,376 [11,663]	Mill expansion completed during year.
Phoenix Copper Division, Greenwood	2,600 [2,400]	0.68 [0.79]	– –	– –	0.26 [0.24]	873,982 [902,325]	5,154 [6,345]	
Granduc Operating Company, Stewart	7,500 [7,500]	1.35 [1.31]	– –	– –	. . . .	2,089,865 [1,498,854]	27,031 [18,821]	

Table 3 (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Jordan River Mines Ltd., Sunro mine, Jordan River, V.I.	1,500 –	. . –	– –	– –	. . –	. . –	. . –	
Lornex Mining Corporation Ltd., Highland Valley	38,000 –	0.43 –	– –	– –	0.03 –	5,468,794 –	20,525 –	Mill tune-up started April 1972. Production officially started Oct. 1, 1972.
Noranda Mines Limited, Bell deposit, Babine Lake	10,000 –	0.66 –	– –	– –	– –	767,270 –	4,163	Production commenced Oct. 1, 1972.
Placid Oil Company, Bull River mine, Cranbrook	700 [750]	1.32 [2.03]	– –	– –	0.38 [0.78]	206,331 [35,528]	2,366 [484]	
Similkameen Mining Company Limited, Ingerbelle pit, Princeton	15,000 –	0.44 –	– –	– –	– –	2,992,664 –	11,500 –	Production started April 1, 1972.
Texada Mines Ltd., Vanada	4,500 [4,500]	0.31 [0.27]	– –	– –	0.02 [0.02]	1,200,429 [1,231,068]	2,179 [2,026]	
Utah Mines Ltd., Island Copper mine, Coal Harbour, V.I.	33,000 [33,000]	0.53 [0.51]	– –	– –	. . . .	7,980,429 [1,040,608]	37,672 [4,020]	Adding secondary, grinding mills in concentrator.
Western Mines Limited, Lynx and Myra mines, Buttle Lake, V.I.	1,100 [1,000]	1.85 [2.00]	6.02 [6.90]	– –	. . [1.60]	374,022 [386,541]	6,577 [6,765]	Addition built on concentrator to allow milling of high-grade silver ore from Myra Falls mine.

Yukon Territory								
Hudson-Yukon Mining Co., Limited, Wellgreen mine, Kluane Lake	600 –	1.35 –	– –	2.05 –	– –	112,451 –	1,258 –	Production started May 1, 1972, but operations to be suspended early 1973; geological problems.
Whitehorse Copper Mines Ltd., Little Chief mine, Whitehorse	2,000 [2,000]	1.92 [1.02]	– –	– –	0.40 . .	10,707 [337,758]	173 [2,618]	Operations suspended June 1971, resumed Dec. 1972, following development of Little Chief underground mine.
Northwest Territories								
Canada Tungsten Mining Corporation Ltd., Tungsten	575 [575]	0.14 [0.15]	– –	– –	– –	172,828 [181,596]	112 [121]	Exploration and development of underground mine continuing.
Echo Bay Mines Ltd., Port Radium	100 [100]	1.14 [0.90]	– –	– –	67.00 [68.90]	37,290 [36,820]	393 [332]	
Terra Mining and Exploration Limited, Camsell River mine, Great Slave Lake	175 [300]	0.38 [0.87]	– –	– –	81.63 [33.70]	24,723 [48,715]	94 [392]	

Source: Company reports.
– Nil; . . Not available; [a]Deliveries.



Producers

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans)
2. British Newfoundland Exploration Limited (Whalesback and Little Deer mines)
   Consolidated Rambler Mines Limited
3. First Maritime Mining Corporation Limited (Gullbridge mine)
5. Dresser Minerals Division of Dresser Industries, Inc. (Walton)
6. Anaconda Canada Limited (Caribou mine)
   Brunswick Mining and Smelting Corporation Limited (No. 6 and No. 12 mines)
   Heath Steele Mines Limited (Newcastle)
   Nigadoo River Mines Limited (Robertville)
7. Gaspé Copper Mines, Limited (Murdochville)
8. Madeleine Mines Ltd. (Gaspé Provincial Park)
10. Sullivan Mining Group Ltd. (Copra, D'Estrie, Weedon mines)
11. Campbell Chibougamau Mines Ltd. (Cedar Bay, Henderson, Kokko Creek, Main mines)
    Icon Sullivan Joint Venture (Chibougamau)
    Patino Mines (Quebec) Limited, Copper Rand Mines Division (Copper Rand, Copper Cliff, Jaculet, Portage mines)
12. Falconbridge Copper Limited, Opemiska Division
13. Renzy Mines Limited (Hainault Township)
14. Louvem Mining Company Inc. (Louvincourt)
    Manitou-Barvue Mines Limited (Val-d'Or)
15. Joutel Copper Mines Limited (Joutel)
    Mattagami Lake Mines Limited (Matagami)
    Orchan Mines Limited (Matagami)
    Rio Algom Mines Limited (Mines de Poirer mine)
16. Normetal Mines Limited (Normetal)
17. Delbridge Mines Limited (Noranda)
    Falconbridge Copper Limited, Lake Dufault Division
    Noranda Mines Limited (Horne mine)
    Quemont Mines Limited (Noranda)
19. Copperfields Mining Corporation Limited (Timagami mine)
20. Upper Beaver Mines Limited (Dobie)
21. Falconbridge Nickel Mines Limited (East, Falconbridge, Fecunis Lake, Hardy, Longvac South, North, Onaping, Strathcona mines)
22. Ecstall Mining Limited (Kidd Creek mine)
    Jameland Mines Limited (Timmins)
    Kam-Kotia Mines Limited (Timmins)
    McIntyre Porcupine Mines Limited (Schumacher)
25. Tribag Mining Co., Limited (Batchawana Bay)
    North Canadian Enterprises Limited (Coppercorp mine)
26. Noranda Mines Limited (Geco Division)
    Willroy Mines Limited (Willecho and Willroy mines)

27. The International Nickel Company of Canada, Limited (Shebandowan)
28. Mattabi Mines Limited (Sturgeon Lake)
29. Selco Mining Corporation Limited (Uchi Lake)
30. Consolidated Canadian Faraday Limited (Werner Lake Division)
31. Dumbarton Mines Limited (Bird River)
32. Falconbridge Nickel Mines Limited (Manibridge mine)
    The International Nickel Company of Canada, Limited (Birchtree, Pipe, Soab and Thompson mines)
33. Hudson Bay Mining and Smelting Co., Limited (Anderson, Chisel, Dickstone, Flexar, Flin Flon, Ghost Lake, Osborne, Schist, Stall and White Lake mines)
34. Sherritt Gordon Mines, Limited (Lynn Lake, Fox Lake, and Centennial mines)
35. Rio Algom Mines Limited (Anglo-Rouyn mine)
36. Placid Oil Company (Bull River deposit)
37. The Granby Mining Company Limited, Phoenix Copper Division
38. Brenda Mines Ltd. (Peachland)
39. Alwin Mining Company Ltd. (Highland Valley)
    Bethlehem Copper Corporation Ltd. (Highland Valley)
    Lornex Mining Corporation Ltd. (Highland Valley)
40. Giant Mascot Mines Limited (Hope)
    Similkameen Mining Company Limited (Ingerbelle and Similkameen deposits)
41. Anaconda Canada Limited, Britannia Mines Division (Britannia Beach)
42. Texada Mines Ltd. (Vananda)
43. Western Mines Limited (Buttle Lake, V.I.)
44. Cominco Ltd. (Coast Copper Mines, V.I.)
    Utah Mines Ltd. (Island Copper mine)
45. Gibraltar Mines Ltd. (McLeese Lake)
46. Bradina Joint Venture
    The Granby Mining Company Limited (Granisle mine)
47. Falconbridge Nickel Mines Limited (Wesfrob mine, Q.C.I.)
48. Granduc Operating Company (Stewart)
50. Churchill Copper Corporation Ltd. (Magnum Creek)
52. Whitehorse Copper Mines Ltd. (Whitehorse)
53. Hudson-Yukon Mining Co., Limited (Wellgreen mine)
54. Terra Mining and Exploration Limited (Sawmill Bay)
55. Echo Bay Mines Ltd. (Port Radium)
56. Jordan River Mines Ltd. (Sunro mine)
57. Canada Tungsten Mining Corporation Limited

Prospective producers

6. Heath Steele Mines Limited (Little River mine)
15. Orchan Mines Limited (Garon Lake mine)
21. Falconbridge Nickel Mines Limited (Lockerby and Thayer Lindsley mines)
34. Sherritt Gordon Mines, Limited (Ruttan Lake)

Exploration projects

4. Union Minière Explorations and Mining Corporation Limited (Thierry deposit)
9. New Quebec Raglan Mines Limited (Wakeham Bay)
21. The International Nickel Company of Canada, Limited (Cryderman, Victoria and Whistle mines)
    Falconbridge Nickel Mines Limited (Fraser and Onex mines)
28. Sturgeon Lake Mines Limited (Sturgeon Lake)
33. Hudson Bay Mining and Smelting Co., Limited (Rail Lake, Reed Lake and Wim mines)
    Stall Lake Mines Limited (Snow Lake)
39. Afton Mines Ltd. (Kamloops)
    Highmont Mining Corp. Ltd. (Highland Valley)
    Valley Copper Mines Limited (Highland Valley)
    Bethlehem Copper Corporation Ltd. (J-A and Maggie zones)
40. Giant Mascot Mines Limited (Canam mine)
43. Catface Copper Mines Limited (Tofino)
49. Davis-Keays Mining Co. Ltd. (Fort Nelson)
51. Liard Copper Mines Ltd. (Telegraph Creek)

Smelters

7. Gaspé Copper Mines, Limited (Murdochville)
17. Noranda Mines Limited (Noranda)
21. The International Nickel Company of Canada, Limited (Coniston)
    The International Nickel Company of Canada, Limited (Copper Cliff)
    Falconbridge Nickel Mines Limited (Falconbridge)
33. Hudson Bay Mining and Smelting Co., Limited (Flin Flon)

Refineries

18. Canadian Copper Refiners Limited
21. The International Nickel Company of Canada, Limited (Copper Cliff)
    The International Nickel Company of Canada, Limited (Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Levack, MacLennan, Murray and Totten mines)

Table 4. Prospective[1] copper producers

Company and Location	Mill Capacity[2] and Ore Grade	Year Production Expected	Destination of Copper Concentrates	Remarks
	(%)			
New Brunswick				
Heath Steele Mines Limited, Newcastle Little River mine	– Cu(. .) Zn(. .)	1975	Murdochville	Present mill capacity to be increased from 3,000 to 4,000 tpd.
Quebec				
Falconbridge Copper Limited, Opemiska Division Chapais Cooke mine	– Cu(. .)	. .	Noranda	Production at 300 tpd to be trucked to Opemiska mill.
Orchan Mines Limited, Matagami Norita mine	– Cu(0.70) Zn(7.60)	1975	Noranda	Production at 900 tpd to be trucked to Orchan mill.
Ontario				
Falconbridge Nickel Mines Limited, Falconbridge	–			Production plans postponed pending improved nickel markets.
Lockerby mine	Cu(. .)	. .	Falconbridge	
Thayer Lindsley mine	Ni(. .)	. .	Falconbridge	
The International Nickel Company of Canada, Limited, Sudbury	– Cu(. .) Ni(. .)			
Crean Hill mine		. .	Copper Cliff	On standby at year-end.
Levack West mine		. .	Copper Cliff	Under development.
Murray mine		. .	Copper Cliff	On standby at year-end.
Totten mine		. .	Copper Cliff	On standby at year-end.
Manitoba				
Hudson Bay Mining and Smelting Co., Limited, Flin Flon Centennial mine	– Cu(2.06) Zn(2.60)	1975	Flin Flon	Development work to start in 1973.
The International Nickel Company of Canada, Limited, Thompson Soab mine	Cu(. .) Ni(. .)	. .	Copper Cliff	On standby at year-end.
Sherritt Gordon Mines, Limited, Ruttan Lake	10,000 Cu(1.47) Zn(1.61)	1973	Noranda	Open pit mining for 6 years followed by underground mining.

[1]Only mines with announced production plans; [2]Mill capacity in tpd of ore.
– Nil; . . Not available.

DISPOSITION OF CANADIAN MINE PRODUCTION OF COPPER, 1972

MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES

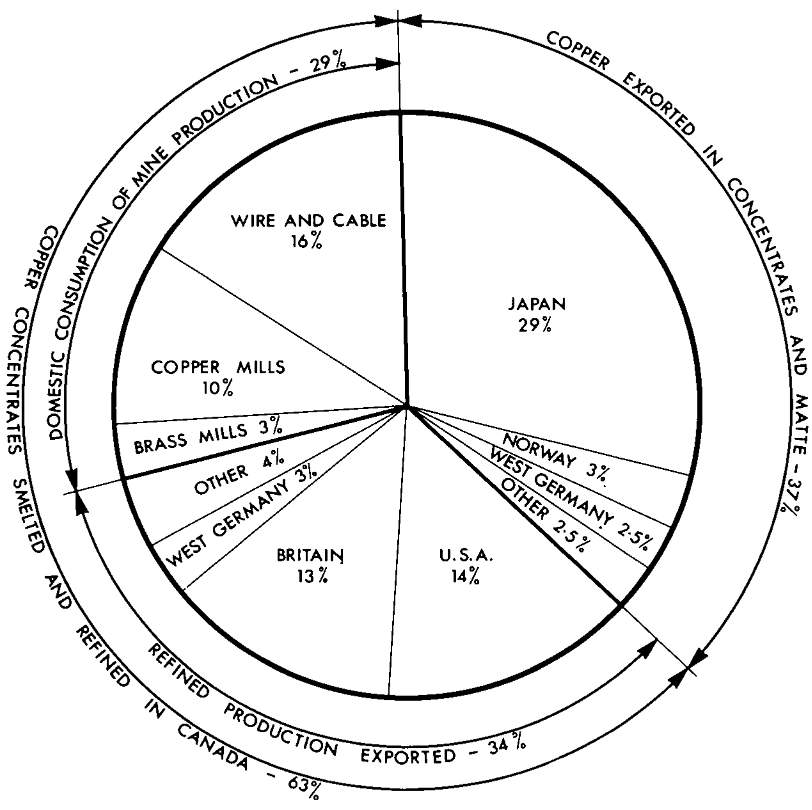


Table 5. Copper exploration projects

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Quebec			
Copperfields Mining Corporation Limited,	1,690,000	Cu(2.25)	
Iso Mines Limited,	2,050,000	Cu(0.40)	
Noranda		Zn(5.50)	
Magusi River deposit			
New Quebec Raglan Mines Limited,	16,050,000	Cu(0.71)	Property held in abeyance.
Wakeham Bay		Ni(2.58)	

Table 5 (cont'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Ontario			
Falconbridge Nickel Mines Limited, Falconbridge			
Fraser mine	..	Cu(. .)	Development work deferred at both mines.
Onex mine	..	Ni(. .)	
The International Nickel Company of Canada, Limited, Sudbury			
Cryderman mine	..	Cu(. .)	
Victoria mine	..	Ni (. .)	
Whistle mine	..		
Sturgeon Lake Mines Limited, Sturgeon Lake	1,928,000	Cu(3.00) Zn(7.85) Ag(4.54 oz/ton)	Preproduction engineering study completed for 1,200-tpd operation.
Union Minière Explorations and Mining Corporation Limited, Pickle Crow	10,000,000	Cu(1.60) Ni(0.29)	
Thierry deposit			
Manitoba			
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake			
Hudvam mine	400,000	Cu(1.50) Zn(1.70)	
Rail Lake mine	325,000	Cu(3.00)	
Reed Lake mine	1,142,000	Cu(2.18)	
Wim mine	1,090,000	Cu(2.91)	
Stall Lake Mines Limited, Snow Lake	672,000	Cu(5.38) Zn(2.28)	
British Columbia			
Afton Mines Ltd., Kamloops	30,000,000	Cu(1.06)	
Bethlehem Copper Corporation Ltd., Highland Valley			
J-A zone	500,000,000	Cu(0.45 equiv.)	Preproduction studies carried out on J-A zone for 25,000-tpd operation.
Maggie zone	200,000,000	Cu(0.40 equiv.)	
Catface Copper Mines Limited, Tofino, V.I.	..	Cu(. .)	
Davis-Keays Mining Co. Ltd., Fort Nelson	1,375,000	Cu(3.38)	
Giant Mascot Mines Limited, Hope			
Giant Copper (Canam) mine	2,600,000	Cu(1.28)	

Table 5 (cont'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Highmont Mining Corp. Ltd., Highland Valley	145,000,000	Cu(0.27) MoS_2(0.045)	Awaiting financing to bring property into production at 25,000 tpd.
Liard Copper Mines Ltd., Schaft Creek	300,000,000	Cu(0.40) MoS_2(0.036)	Surface diamond drilling continuing.
Stikine Copper Limited, Stikine River area	59,000,000 45,000,000	Cu(1.20) Cu(1.00)	Surface diamond drilling continuing.
Valley Copper Mines Limited, Highland Valley	600,000 per vertical foot	Cu(0.46)	

. . Not available.

Smelters and refineries. A summary of the six Canadian smelters that treat copper-bearing materials is given in Table 6. Inco suspended operations at the Coniston smelter in April 1972, but all other plants operated normally.

The operations of the two Canadian copper refineries are summarized in Table 7.

Construction continued on the major smelter and refinery expansion program, scheduled for completion in 1973, of Noranda Mines Limited in Quebec. At Murdochville, smelter capacity will be raised by 27,000 tons of anode copper a year. A 300,000-ton-a-year sulphuric acid plant is under construction and some of the acid produced will be used to leach copper from low-grade oxide ores from the Copper Mountain mine. At Noranda, the smelter is being expanded by the construction of a Noranda Continuous Smelting Process reactor capable of producing 55,000 tons a year of blister copper in one furnace directly from concentrates. Operation of the reactor is to start early in 1973. During the year, expansion of Noranda's copper refinery, Canadian Copper Refiners Limited (C.C.R.) at Montreal East, to an annual capacity of about 420,000 tons of refined copper was completed. This expansion was accomplished by introducing Periodic Reversal of Current (PRC) to the electrodeposition process in the larger of the two tankhouses. Late in the year, a further expansion of 60,000 tons a year was announced. This will necessitate adding 18 more electrolytic cell sections in the smaller tankhouse and, when completed late in 1973, will make C.C.R. the world's largest copper refinery.

Hudson Bay Mining and Smelting Co., Limited has announced plans to erect an 825-foot steel-lined smokestack at its smelter at Flin Flon, Manitoba to improve the dispersion of sulphur gases. Hudson Bay will also install facilities to produce anode copper instead of blister copper.

At Inco, copper refining capacity was being expanded by 10 per cent through the installation of an electrowinning circuit to recover copper as a by-product from the new nickel refinery.

Four companies sell refined copper in Canada. They are Noranda Mines Limited, The International Nickel Company of Canada, Limited (Inco), Texas Gulf, Inc., and Hudson Bay Mining and Smelting Co., Limited. Noranda sells copper that it produces from concentrates obtained from its own and affiliated companies, from concentrates treated on a custom basis, and from scrap. Inco sells copper produced from its nickel-copper mines at Sudbury, Ontario, and Thompson, Manitoba. Texas Gulf produces copper concentrates at its Ecstall mine at Timmins, Ontario; these are smelted and refined by Noranda on a toll basis. Noranda also toll refines blister copper from the Hudson Bay smelter at Flin Flon, Manitoba.

Consumption. Eight fabricating and semifabricating companies use 90 to 95 per cent of the refined copper sold in Canada. Four of these companies are rod rollers that make wire rod for their own and other wire drawing operations. The other four companies own copper and brass mills that make sheet, strip, bars, pipe, tubes, etc.

Of the copper reported to have been consumed by the fabricating and semifabricating companies (Table 8), about half is used for wire and cable, a third for copper mill products, and a sixth for brass mill products. Less than 1 per cent is used for miscellaneous items that include chemicals.

Canadian consumption of copper in 1972 was about normal as compared to the previous eight years, and no growth patterns were apparent.

Table 6. Canadian copper and copper-nickel smelters, 1972

Company and Location	Product	Rated Annual Capacity	Remarks	Ore and Concentrate Treated	Blister or Anode Copper Produced
		(tons)		(tons)	(tons)
Falconbridge Nickel Mines Limited Falconbridge, Ont.	Copper-nickel matte	650,000[2]	Copper-nickel ore and sintered concentrate smelted in blast furnaces; converted to produce matte for shipment to company's electrolytic refinery in Norway.	. .	. .
Gaspé Copper Mines, Limited Murdochville, Que.	Copper anodes, metallic bismuth	370,000[1]	One reverberatory furnace for green-charge concentrates, 2 Pierce-Smith converters, 1 anode furnace, 1 walker casting wheel. Also smelts custom concentrates.	354,800 (of which 118,000 were custom concentrates	63,816
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	Blister-copper cakes	575,000[1]	Roasting furnaces, 1 reverberatory furnace, 3 converters. Treats own and custom copper concentrates along with zinc plant residues in conjunction with slag-fuming furnaces.	414,325 (of which 58,378 were custom concentrates)	54,897
The International Nickel Company of Canada, Limited Coniston, Ont.	Copper-nickel Bessemer matte	800,000[1]	Sintering; blast furnace smelting of nickel copper ore and concentrate; converters for production of copper-nickel Bessemer matte. Plant operations suspended in April 1972.	. .	. .
Copper Cliff, Ont.	Blister copper, nickel sulphide and nickel sinter for company's refineries; nickel oxide sinter for market	4,000,000[1]	Oxygen flash-smelting of copper sulphide concentrate; converters for production of blister copper. Blast furnaces, roasters, reverberatory furnaces for smelting of copper-nickel ore and concentrate; converters for production of copper-nickel Bessemer matte. Production of matte followed by matte treatment, flotation, separation of copper and nickel-sulphides then by sintering to make sintered-nickel products for refining and marketing. Electric-furnace melting of copper sulphide and conversion to blister copper.	. .	. .

Table 6 (cont'd)

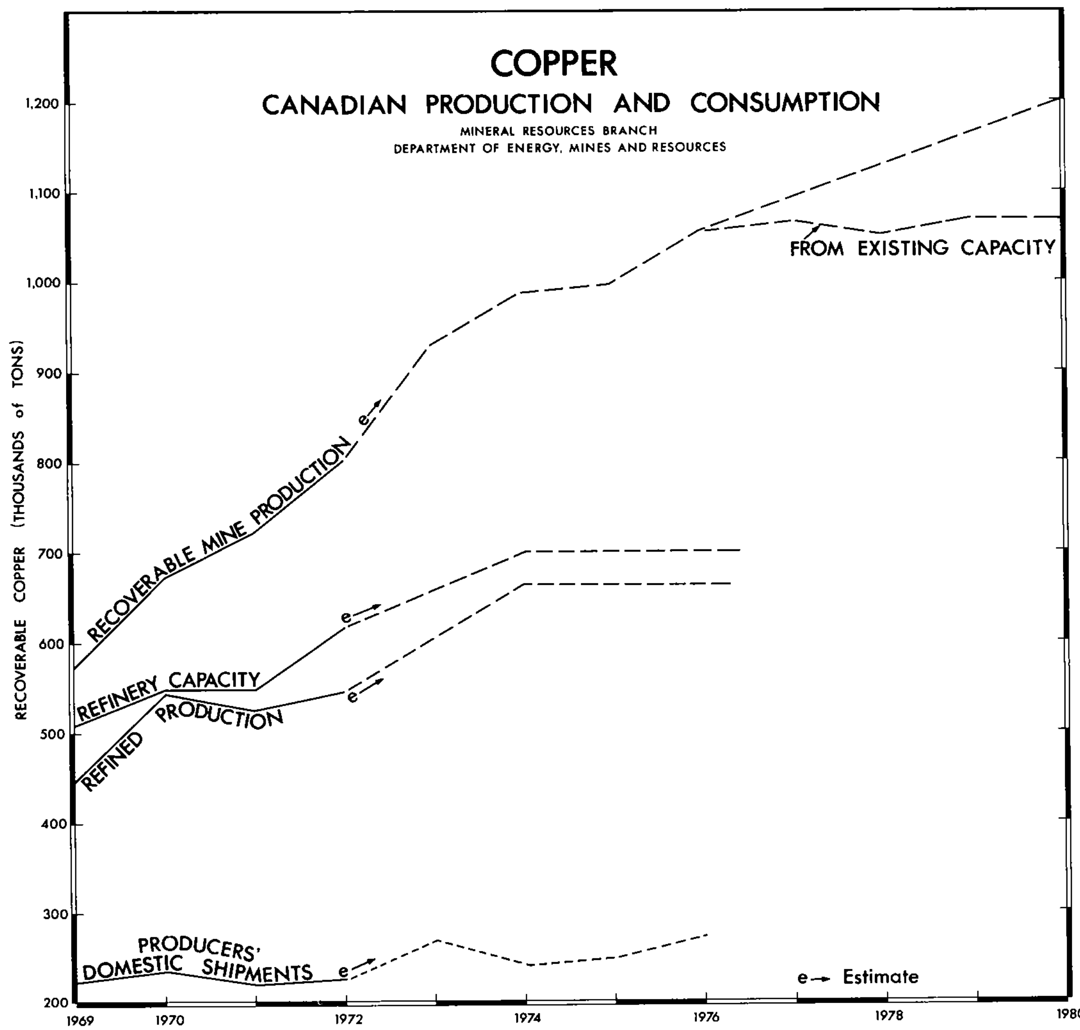
Company and Location	Product	Rated Annual Capacity	Remarks	Ore and Concentrate Treated	Blister or Anode Copper Produced
		(tons)		(tons)	(tons)
Noranda Mines Limited, Noranda, Que.	Copper anodes	1,700,000[2]	Roasting furnaces; 2 hot-charge and 1 green-charge reverberatory furnaces; 5 converters. Also smelts custom material.	1,485,000 (of which 780,000 were custom concentrates)	236,000

Source: Company reports.
. . Not available. [1]Ores and concentrates. [2]Ores, concentrates and scrap.

Table 7. Copper refineries in Canada, 1972

Company and Location	Rated Annual Capacity	Output	Remarks
	(tons)	(tons)	
Canadian Copper Refiners Limited, Montreal East, Que.	420,000	376,000	Refines anodes from Noranda and Gaspé smelters, blister copper from Flin Flon smelter, and purchased scrap. Copper sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from anode slimes. Produces C.C.R. brand electrolytic copper wire bars, ingot bars, ingots, cathodes, cakes and billets.
The International Nickel Company of of Canada, Limited Copper Refining Division, Copper Cliff, Ont.	198,000	154,000[d]	Refines blister copper from Copper Cliff smelter. Also some custom refining. Precious metals, selenium and tellurium are recovered from anode slimes. Produces ORC brand electrolytic copper, cathodes, wire bars, cakes, billets, ingots and ingot bars.

Source: Company reports.
[d]Deliveries.



Federal government action

The federal government played a more active role in the copper industry in 1972 than in 1971. Late in March, The Honourable Donald S. Macdonald, Minister of Energy, Mines and Resources, became concerned with the growing series of requests made by Japanese smelters to Canadian copper concentrate exporters for the opening of existing contracts and the renegotiation of contract terms. Consequently, the Minister asked the Canadian companies involved to refrain from making any amendments to established legal obligations until the end of April to allow the government to study the situation. The Japanese smelters generally were requesting reductions in concentrate delivery by up to 20 per cent, increased treatment charges to compensate the smelters for the expense of pollution-abatement equipment, and an allowance of 16.88 per cent on treatment charges to cover revaluation of the yen. After completing its investigation, the government advised the Japanese government of its concern for the impact which the requested changes could have on the Canadian copper industry and its related communities. The companies were notified that they were free to continue negotiations, and the Canadian government undertook to discuss the principles involved with the Japanese government. At the end of the year, all company negotiations had been satisfactorily completed.

Table 8. Canada, consumption of primary copper in manufacture of semifabricated products, 1970-72

	1970	1971	1972
	(short tons)		
Copper mill products – sheet, strip, bars, rolls, pipe, tubes, etc.	66,833	61,131	60,183
Brass mill products – plate, sheet, strip, rods, bars, rolls, pipe, tubes, etc.	28,483	19,951	23,621
Wire and rod mill products	97,806	99,682	107,540
Miscellaneous	1,745	1,636	2,131
Total	194,867	182,400	193,475

Source: Statistics Canada.

World supply and demand

Mines. World mine production of copper for 1971 and 1972 is shown in Table 9.

Production for all countries, except Japan, rose during 1972; the most impressive increases being in the United States, Canada, and the U.S.S.R. Preliminary statistics indicate that Canadian production rose sufficiently to place Canada ahead of both Chile and Zambia. Chilean production rose by 13,400 tons although operations continued to be hampered by strikes and a shortage of skilled technical personnel.

Table 12 attempts to break the world copper industry into segments to show the relative importance of the various trading areas. The United States is a small net importer of copper; the U.S.S.R. is an exporter, but the communist bloc as a whole is a net importer, mainly because China is a large net importer. Japan and Europe are large importing areas that are supplied by exports from the four CIPEC nations (Intergovernmental Council of Copper Exporting Countries, which are Chile, Peru, Zaïre, and Zambia), Canada, and the increasingly important group listed as 'other noncommunist countries'. This group had mine production of 1,113,900 tons of contained copper in 1972 versus 842,300 tons in 1971.

Within the group of other noncommunist countries, a subgroup is emerging. This subgroup is made up of nonaligned, less-developed countries scattered around the globe that have substantial mine production of copper or a large potential production. Some of these countries are the Philippine Republic, Papua in New Guinea, Indonesia, Iran, Panama, Argentina, and Brazil. These countries will become increasingly important sources of copper over the medium to long term as European and Japanese consumers search for further diversification of supply, an assured quantity of concentrates, and outlets for investment capital.

Expansion of the world copper mining industry will continue for the next few years but at a reduced scale from the near past. Mine production should increase by about 9 per cent in 1973, by 5 per cent in 1974, and 6 per cent in 1975. Most of the expansion will take place in the United States, the U.S.S.R., Poland, Australia, Turkey, the Philippines, Malaysia, Indonesia, Zaïre, and Zambia. Other new mine capacity is scheduled for West Irian, Spain, Mauritania, India, and Yugoslavia.

Smelters and refineries. The world production of refined copper for 1971 and 1972 is shown in Table 10.

There is only limited expansion in progress of world smelting and refining capacity. Japan has largely completed its expansion and modernization program, and expansion of smelting facilities is under way in Australia, Canada, Turkey, India, Finland, Peru, and the United States.

Research into better methods of reducing copper sulphide ores and concentrates to metal is continuing on two fronts – hydrometallurgy and continuous smelting. Most hydrometallurgical research programs are still at the laboratory or pilot plant stage and large-scale commercial adaptation of any design is a few years away. Continuous smelting, however, is

Table 9. World mine production of copper, 1971-72

	1971	1972
	(000 short tons)	
United States	1,522.2	1,642.8
U.S.S.R.	1,091.3[e]	1,157.4[e]
Canada	721.4	801.7
Chile	780.8	794.2
Zambia	718.0	790.5
Zaïre	447.3	471.8
Peru	234.7	239.2
Philippines	217.6	226.0
Australia	192.0	203.9
Republic of South Africa	163.6	171.3
People's Republic of China	143.3[e]	145.5[e]
Papua, New Guinea	–	136.7
Yugoslavia	118.3	136.6
Japan	133.4	125.1
Poland	98.1	105.8
Mexico	69.7	70.1
Other communist countries	82.1[e]	86.0[e]
Other noncommunist countries	358.1	364.4
Total	7,091.9	7,669.0

Sources: World Metal Statistics, April 1973, and Statistics Canada.
[e]Estimated.

Table 10. World production of refined copper, 1971-72

	1971	1972
	(000 short tons)	
United States	1,961.0	2,190.9
U.S.S.R.	1,267.6[e]	1,349.2
Japan	786.3	893.0
Zambia	589.0	678.1
Canada	526.4	546.7
Chile	515.7	463.3
West Germany	441.0	439.3
Belgium	344.8	343.9
Zaïre	229.1	241.4
Britain	206.8	199.2
Australia	179.8	186.2
People's Republic of China	165.4[e]	172.0[e]
Yugoslavia	102.1	143.3
Poland	102.2	119.0
Spain	80.7	92.6
Republic of South Africa	87.3	87.4
Mexico	65.8	70.2
Sweden	54.7	56.9
Other communist countries	140.7[e]	138.9[e]
Other noncommunist countries	243.7	260.5
Total	8,090.1	8,672.0

Source: World Metal Statistics, April 1973.
[e]Estimated.

Table 11. World consumption of refined copper, 1971-72

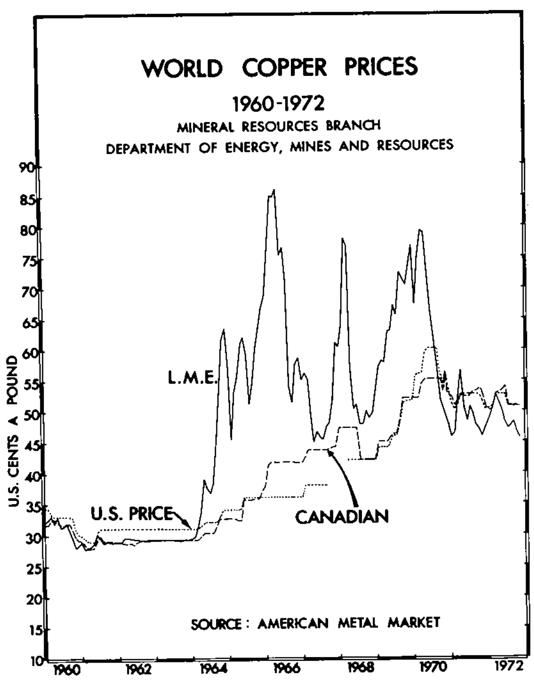
	1971	1972
	(000 short tons)	
United States	2,016.0	2,237.0
U.S.S.R.	1,135.4[e]	1,190.5[e]
Japan	910.8	1,051.7
West Germany	695.0	748.1
Britain	563.6	578.4
France	378.8	414.2
Italy	297.6	303.8
People's Republic of China	275.6[e]	277.8[e]
Canada	243.0	246.7
Belgium	125.0	139.3
Spain	114.0	136.7
Sweden	100.8	107.5
Australia	121.7	106.0
Brazil	86.2	99.6
East Germany	99.2	99.2
Yugoslavia	74.9	69.8
Other communist countries	231.5[e]	231.5[e]
Other noncommunist countries	510.5	512.0
Total	7,979.6	8,549.8

Source: World Metal Statistics, April 1973.
[e]Estimated.

Table 12. World copper production and consumption, 1972

	Mine Production	Refined Production	Refined Consumption
	(000 short tons)		
United States	1,642.8	2,190.9	2,237.0
U.S.S.R.	1,157.4[e]	1,349.2[e]	1,190.5[e]
Japan	125.1	893.0	1,051.7
CIPEC	2,295.7	1,425.7	41.3
Europe	300.9	1,419.2	2,693.4
Canada	801.7	546.7	246.7
Other communist countries	231.5[e]	310.9[e]	509.3[e]
Other noncommunist countries	1,113.9	536.4	579.9
Total	7,669.0	8,672.0	8,549.8

Sources: World Metal Statistics, April 1973, and Statistics Canada.
[e]Estimated.



farther along. As mentioned previously, Noranda Mines is constructing a commercial unit at Noranda. In addition, the Mitsubishi interests are operating a pilot plant of their own design at the Onahama smelter in Japan and the Conzinc-Rio Tinto group has financed a pilot plant operation of the Worcra process in Australia. Two or three years of testing are anticipated for the Mitsubishi process. The Worcra research personnel have completed tests and are trying to arrange financing to construct a semicommercial plant. Continuous smelting, with apparently low construction and operating costs, shows promise of replacing conventional smelting in the medium term.

Consumption. The consumption of refined copper in the world for 1971 and 1972 is shown in Table 11.

Consumption grew in all countries in 1972, except in Australia and Yugoslavia. The growth was especially apparent in the United States (220,000 tons or 10%), and was attributed to the economic recovery that occurred in that country in 1972. Growth in Europe and Japan was more moderate, but can be expected to improve in these areas in 1973.

Uses

Copper's properties of malleability, ductility, conductivity, corrosion resistance, alloying qualities and pleasing appearance make its use universal in the electrical, construction, plumbing and automotive industries. Approximately half of all copper consumed is for electrical applications, including power transmission, electronics and electrical equipment, and transportation. Generation and utilization of electrical energy requires very large quantities of copper for heat exchangers, bus bars, magnet wire, and windings in motors, generators and transformers.

The noncorrosive qualities of copper and its alloys account for many uses in construction, for plumbing goods, builders' hardware, and roofing products. Copper alloys are used in bearings, fastenings and fittings for marine hardware. In the automotive industry, copper is used in radiators, wires, bearings, bushings, switches and oil lines.

The principal copper and brass fabricators in Canada are: in British Columbia – Norco Industries Ltd. (formerly Noranda Metal Industries Ltd.), Vancouver; in Ontario – Anaconda Canada Limited, Toronto; Phillips Cables Limited, Brockville; Ratcliffs (Canada) Limited, Richmond Hill; Wolverine Tube Division of UOP Company Limited (formerly Calumet & Hecla (Canadian) Limited), London; in Quebec – The Noranda Copper Mills Limited, Montreal East; Pirelli Cables Limited, St-Jean; Northern Electric Company, Limited, Montreal; and Canada Wire and Cable Company, Limited, Montreal.

Prices

The LME cash copper price was equivalent to 47.37 cents U.S. a pound at the start of 1972, virtually unchanged from a year earlier. It rose to a high of 53.06 cents on March 21 but fell gradually to the 45 to 46 cent range at year-end.

The U.S. producers' price opened 1972 at 50.25 – 50.50 cents U.S. a pound, rose to 52.50 – 52.75 cents late in February and dropped to 50.50 – 50.75 early in July, where it remained until year-end.

The Canadian producers' price was quoted at 50.375 cents Canadian a pound at the start of January 1972. It was raised to 52.625 cents on February 28 and lowered to 49.75 cents on July 6. On December 8, it was raised to 50.50 cents to compensate for the changing value of the Canadian dollar. These prices were quoted by Noranda Sales Corporation Ltd., Hudson Bay Mining and Smelting Co., Limited and Texas Gulf, Inc. The International Nickel Company of Canada, Limited, was quoting the Canadian dollar equivalent of the United States producers' price as its domestic price throughout the year.

Outlook

Canadian mines should produce about 925,000 tons of recoverable copper in concentrates in 1973; this is about 125,000 tons more than in 1972. It should be noted that labour difficulties at some plants could reduce this forecast. Output of refined copper should expand appreciably as Noranda's new smelter capacity comes on stream and the refinery is more fully utilized. Sales of refined products will likely be maintained, and perhaps slightly expanded, in all normal markets.

Internationally, the threatened shortage of smelter capacity that was indicated a year ago apparently will not occur. New mine production is finding a home, although some adjustments to original marketing arrangements have been necessary. Minor realignments of some markets for refined copper will develop in 1973 as consuming nations diversify their purchase patterns to assure a dependable supply.

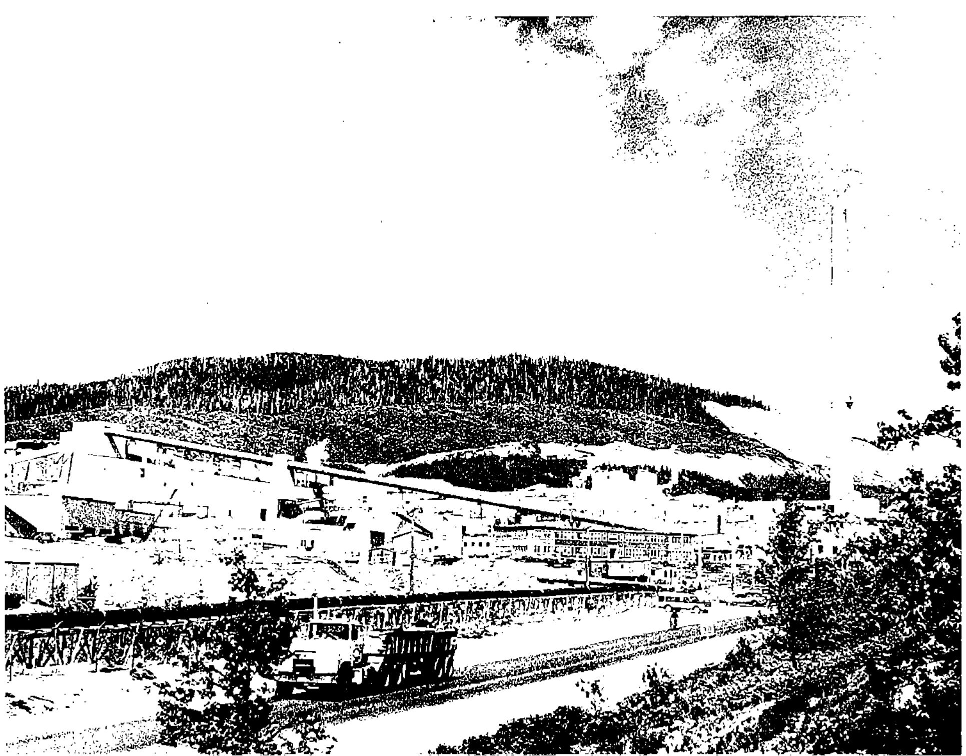
Tariffs

Canada Item No.		British Preferential	Most Favoured Nation	General
			(%)	
32900-1	Copper in ores and concentrates	free	free	free
34800-1	Copper in pigs, blocks, or ingots, cathodes, plates, copper matte, and blister and copper scrap, per lb	free	free	1½¢
				(%)
33503-1	Copper oxides	free	15	25
34820-1	Copper in bars or in rods, for manufacture of trolley, telegraph, telephone wires, electric wires and cables	free	5	10
34835-1	Electrolytic copper powder (expires Feb. 28, 1975)	free	free	10
34845-1	Electrolytic copper wire bars, per lb expires Feb. 28, 1974)	free	free	1½¢
35800-1	Anodes of copper	free	free	10

United States Item No.		On and After January 1		
		1970	1971	1972
			(¢ per lb)	
602.30	Copper ores and concentrates, on Cu content	1.1	1	0.8
612.06	Unwrought copper, on Cu content	1.1	1	0.8
612.10	Copper waste and scrap, on 99.6% of Cu content	1.1	1	0.8

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Gaspé Copper Mines Ltd. (Murdochville, P.Q.). New mill and roaster plant at left. (George Hunter photo).



Fluorspar

G.H.K. PEARSE

Fluorspar, or fluorite in mineralogical nomenclature, is calcium fluoride (CaF_2), an industrial mineral with a broad spectrum of uses. The most important uses are: for the manufacture of hydrofluoric acid and other fluorine chemicals; as a fluxing agent in various metallurgical processes, the most important being steel manufacture; for the manufacture of artificial cryolite, an essential cell ingredient in the electrolytic reduction of alumina to aluminum; in the refining of uranium ores, and in the glass and ceramic industries.

In the past decade world fluorspar consumption has grown rapidly because of increasing demands in the steel, aluminum and chemical industries. In 1972 world consumption reached an estimated 5.0 million short tons* and, based on forecast demands by the major consuming industries, consumption is expected to exceed 7 million tons by 1975. Contributing to this increase will be a greater use of the basic oxygen process in steelmaking, which requires about three times as much fluorspar as a slag thinner than the more traditional basic openhearth process. Ever-widening usage of fluorocarbons and other fluorine chemicals will continue to stimulate world demand for acid-grade material.

Production in Canada

Fluorspar is the principal source of the element fluorine. It occurs in many geological environments from low-temperature fracture fillings to high-temperature emplacements and as a result it is not restricted to any particular geological province in Canada. In fact, fluorspar is known to occur in all physiographic provinces with the exception of the interior plains. However, all fluorspar produced in Canada is currently mined from the Burin Peninsula in Newfoundland by one company.

Newfoundland Fluorspar Works of Aluminum Company of Canada, Limited (Alcan), produces fluorspar from three mines, the Director, the Tarefare, and the Blue Beach located near the village of St. Lawrence in Newfoundland. The Director mine has been in operation for 30 years. In August 1968 the Tarefare commenced production at about 25,000 tons a year of fluorspar concentrate. Production from the Blue Beach began in 1972 and the mill capacity was increased to 1,200 tons per day. Concentrates from these operations are shipped to Alcan's aluminum smelter at Arvida, Quebec, where they are upgraded and converted to artificial cryolite for the reduction of alumina to aluminum. Small tonnages are sold to Newfoundland Steel (1968) Company Limited for steel slagging. In 1972, shipments totalled an estimated 160,000 tons, valued at $5.3 million, approximately double 1971 production which was reduced by a 5-month strike.

Allied Chemical Canada, Ltd. imports acid-grade fluorspar for the production of hydrofluoric acid at the company's plant located at Valleyfield, Quebec. Some of the acid is utilized in the manufacture of various fluorine chemicals. Allied Chemical operates mines in Mexico and the United States to ensure an uninterrupted supply of fluorspar. The company established a new hydrofluoric acid plant at Amherstburg, Ontario in mid-1971.

Huntingdon Fluorspar Mines Limited with a plant near North Brook, Ontario, imports metallurgical-grade fluorspar to make 5-pound briquettes for foundry use.

International Mogul Mines Limited continued assessment of barite-fluorite deposits east of Lake Ainslie, Cape Breton Island, Nova Scotia. Indicated ore reserves are 2.97 million tons grading 28 per cent barite and 19 per cent fluorite. Pilot plant testing initiated in 1969 continued during 1972 with the objective of producing an acid-grade concentrate at an acceptable rate of recovery. From 1940 to 1949 approximately 1,400 tons of fluorspar along with some barite was recovered from this deposit.

Prior to World War I, small tonnages of fluorspar were mined from vein-type deposits in the Madoc district of Ontario. As a strategic material of great importance it showed a marked increase in production during the war. After World War I production decreased substantially but was stimulated once again during World War II by government assistance for exploratory drilling programs and by loans on capital equipment. From 1943 to 1947 some 25,000 tons were mined. Fluorspar was mined continuously in the Madoc area up to 1961 when severe underground flooding, lack of export markets, and increased mining costs made mining uneconomic. Altogether, some 150,000 tons of fluorspar were mined in the Madoc area, production being derived from 24 separate properties. Most significant producing properties were along a prominent linear vein structure, the southern extension of which could still contain economically attractive reserves.

The Rock Candy mine, near Grand Forks, British

*All tons are short tons of 2,000 pounds unless otherwise specified.

Table 1. Canada, fluorspar production, trade and consumption

	1971		1972[p]	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Newfoundland	. .	2,819,091	. .	5,300,000
Imports				
Mexico	158,102	7,251,000	51,075	2,777,000
Britain	26,232	1,130,000	10,566	639,000
Spain	11,270	631,000	7,398	498,000
United States	12,651	787,000	2,871	233,000
Italy	16,838	970,000	–	–
Total	225,093	10,769,000	71,910	4,147,000

	1970	1971
	(short tons)	
Consumption[1] (available data)		
Metallurgical flux[2]	38,352	22,241
Glass and glass wool	1,450	654
Enamels and frits	213	278
Others[3]	172,934	174,427
Total	212,949	197,600

Source: Statistics Canada.
[1]As reported by consumers; breakdown by Mineral Resources Branch. [2]Consumption as flux in the production of steel and magnesium, and use in foundries. [3]Includes consumption in the production of aluminum and chemicals and other miscellaneous uses.
[p]Preliminary; . . Not available for publication; – Nil.

Columbia was mined intermittently from 1918 to 1942 and is still controlled by Cominco Ltd. Substantial reserves probably remain.

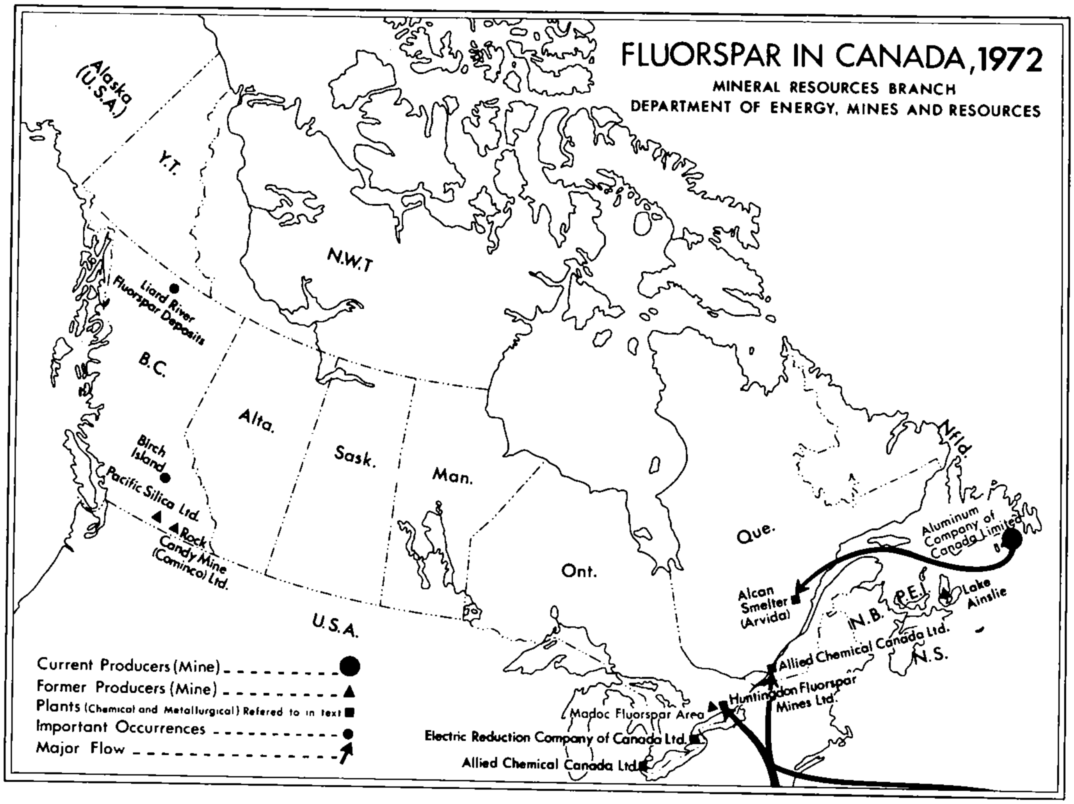
Some fluorine is being recovered as fluosilicic acid from the processing of phosphate rock by Erco Industries Limited (formerly Electric Reduction Company of Canada, Ltd.), at Port Maitland, Ontario, and by Cominco Ltd., at Trail, British Columbia.

Exploration

Strong demand growth during the 1960's coupled with a somewhat stagnant world reserve growth picture and higher prices reactivated vigorous exploration for fluorspar over the last few years both in Canada and abroad.

Fluorspar veins on Burin Peninsula are genetically related to two large stocks of alaskite. Most of this favourable area is obscured by shallow overburden and innumerable showings and float blocks containing fluorspar are known. Combustion Engineering Inc. and Allied Chemical, Canada Ltd. have undertaken intensive exploration programs on the Burin Peninsula immediately north of Aluminum Company of Canada, Limited's operations. The Madoc district of southern Ontario, where fluorspar was produced for many years, has recently attracted some interest. Jorex Limited in a joint venture with Conwest Exploration Company Limited staked and commenced evaluation of fluorspar occurrences in the Liard River area in northern British Columbia in mid-1971. Diamond drilling to date has indicated significant tonnage of fluorspar amenable to open pit mining. Barite and witherite occur as accessory minerals. Because of prohibitive transportation costs from this remote area to available markets, development has been suspended.

Consolidated Rexspar Minerals & Chemicals Limited has a large medium-grade fluorspar deposit adjacent to Canadian National Railways' line at Birch Island, about 60 miles north of Kamloops. Although it is fine-grained and difficult to concentrate, higher prices have stimulated renewed interest in this deposit. A program of diamond drilling, geological



mapping and metallurgical testing was initiated in 1970 to augment earlier work. Geological work indicates the possibility of multiple ore-bearing structures and an assessment of these is planned. Metallurgical testing continued during 1972. Denison Mines Limited is conducting these investigations under terms of an agreement with Consolidated Rexspar.

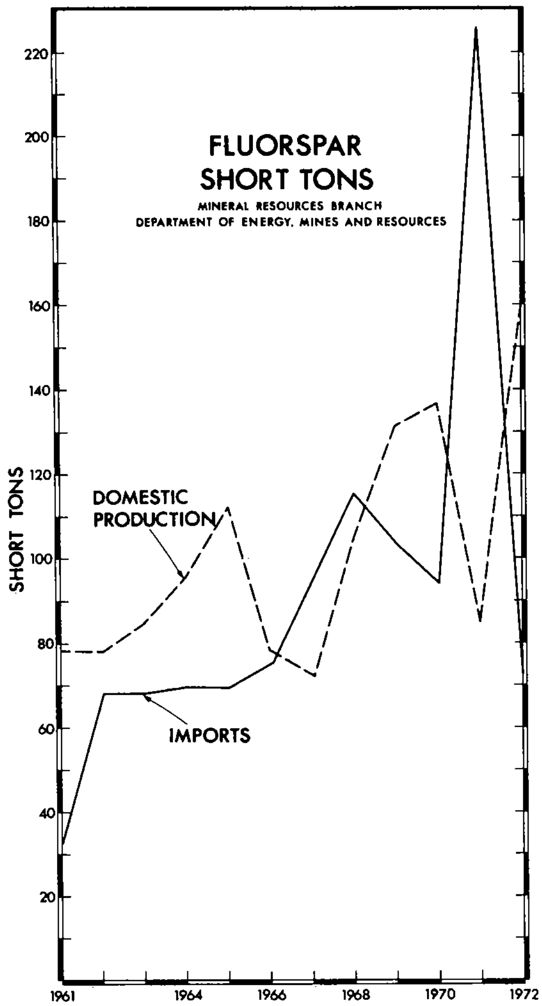
Although not located in Canada, a Canadian company, Lost River Mining Corporation Limited, a subsidiary of Pan Central Explorations Limited, is working on an extensive fluorspar-tin-tungsten deposit in Alaska. Some 32.3 million tons of ore grading 15 per cent CaF_2 have been indicated in one ore zone and an additional 6.3 million tons grading 31.0 per cent CaF_2 in another. Drilling on a third ore zone indicates the presence of a new, major high-grade deposit averaging approximately 30 per cent CaF_2 over widths of 30 to 75 feet. A feasibility study was in progress during 1972 and a target date for beginning production at a rate of 4,000 tons a day has been set for 1976.

Uses, markets and trade

The most important uses of fluorspar are: as a fluxing material in metallurgical and related industries; in the chemical industry for the manufacture of hydrofluoric acid and other fluorine compounds; in the glass and ceramic industries; in the refining of uranium ores and concentrates; and in the manufacture of artificial cryolite utilized in aluminum refining. Minor quantities of clear, transparent, colourless fluorite are used in optical equipment.

Flurospar is marketed in three grades according to end use, although in times of shortage, high-grade material may be substituted in applications normally requiring lower-grade materials. These three grades are acid grade containing a minimum of 97 per cent CaF_2, metallurgical grade containing 60-80 per cent CaF_2 and ceramic grade containing 88-97 per cent CaF_2.

Acid grade. Over 50 per cent of the world's fluorspar requirements are as acid grade and, as the term implies, are used in the manufacture of hydrofluoric acid. Most of this material is beneficiated by flotation to achieve the high CaF_2 content required. In general 2 to 3 tons of ore must be mined to produce 1 ton of acid-grade fluorspar concentrate and the production of



1 ton of hydrofluoric acid requires 2 tons of acid-grade concentrate and almost 3 tons of sulphuric acid. Hydrofluoric acid is produced according to the reaction $CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$ and has a variety of uses but by far the most important, accounting for some 80 per cent, are the aluminum and fluorocarbon industries.

About one third of all hydrofluoric acid produced is used by the aluminum industry. Hydrofluoric acid is reacted with a sodium salt and aluminum fluoride to produce artificial cryolite, an essential cell ingredient for fluxing in the electrolytic reduction of alumina to aluminum. In general, about 45 pounds of cryolite and 40 pounds of aluminum fluoride are required for the production of 1 ton of primary aluminum. This is equivalent to approximately 130 to 140 pounds of acid-grade fluorspar concentrate. Allowing for increased cell efficiencies and fluorite recoveries from potlines the above figure should be reduced to 120 pounds per ton of primary aluminum. Because fluorite is an essential raw material, many primary aluminum producers operate or participate in the operation of fluorspar mines to ensure uninterrupted and adequate supplies.

Over 40 per cent of hydrofluoric acid is consumed in the manufacture of fluorocarbons. Fluorocarbons, used in the manufacture of solvents, resins, plastics, films, refrigerants and aerosol propellants, are produced by reacting hydrofluoric acid with carbon tetrachloride or with chloroform.

Fluorspar is used in uranium refining. Uranium dioxide is reacted with anhydrous hydrofluoric acid to form a green salt (UF_4), which is then reacted with elemental fluorine in the form of fluorine gas to form UF_6. For each ton of uranium processed into uranium hexafluoride, 1 2/3 tons of fluorspar are required.

Metallurgical grade. About one half of the world's fluorspar output is consumed as a metallurgical fluxing agent, primarily in the manufacture of steel. Metallurgical-grade fluorspar is used in the steel industry to remove impurities during melting and also to improve separation of metal and slag in the furnace by increasing the fluidity of the slag. Consumption of fluorspar in the steel industry has, in recent years, increased substantially because of increased steel

Table 2. Canada, fluorspar production, trade and consumption, 1963-72

	Production	Exports	Imports	Consumption
	(short tons)			
1963	85,000[2]	4	66,798	142,840
1964	96,000[2]	..	69,986	155,828
1965	112,000[2]	..	69,848	167,537
1966	79,000[1]	12	75,324	166,275
1967	72,752[1]	..	94,244	155,349
1968	105,000[1]	..	115,465	178,901
1969	131,600[1]	..	104,382	200,827
1970	136,800[1]	..	94,682	212,949
1971	85,000[e]	..	225,093	197,600
1972[p]	160,000[e]	..	71,910	..

Source: Statistics Canada.
[1]Estimates reported by U.S. Bureau of Mines. [2]Shipments reported in annual reports of *Aluminum Company of Canada, Limited.*
[p]Preliminary; .. Not available; [e]Estimate.

output and changing technology. Steelmakers have shifted increasingly from the basic open hearth process to the basic oxygen process. The latter consumes from 10 to 15 pounds of metallurgical-grade fluorspar compared with 3 to 5 pounds in the open hearth process. The electric furnace process consumes from 8 to 10 pounds of metallurgical-grade material for each ton of steel produced. The basic oxygen process substantially reduces production costs, doubles capacity per unit dollar of capital cost and reaches heat much faster than the open hearth process. Within the next decade older basic open hearth furnaces should be replaced by the more efficient new basic oxygen or electric furnaces. Faced with higher prices and uncertain supply conditions, the steel industry will attempt to find methods to reduce consumption of fluorspar. In addition, some major consumers have become involved in exploration for fluorspar reserves. No satisfactory substitute for fluorspar as a fluxing agent in steelmaking has been found, although research in this area is considerable and indications are that the growth of metallurgical-grade reserves is not keeping pace with requirements. Consequently, steelmakers may have to switch to higher-grade, higher-cost material, produced as flotation concentrates in pellet or briquette form. World consumption in the steel industry is forecast to increase from a current level of 3.0 million tons to 3.9 million tons in 1975. Metallurgical-grade fluorspar is also used as a flux in foundries and in the reduction of dolomite to magnesium.

Ceramic grade. Ceramic-grade fluorspar is used as an opacifier in enamels and opal glass. It is also used to a limited extent in the manufacture of clear glass as an active flux, a contributor to the gloss and as a decolourizer. Much of this grade of fluorspar concentrates could be used for the manufacture of hydrofluoric acid or as pellets and briquettes for steelmaking.

Canadian consumption and trade

Most fluorspar consumed in Canada and virtually all domestic production is used in the manufacture of artificial cryolite (Na_3AlF_6) for the electrolytic reduction of alumina to aluminum.

In 1971 fluorspar imports were 225,093 tons, an all-time high, because of reduced domestic output, resulting from a five-month strike at Alcan's Newfoundland Fluorspar Works. In 1972, imports dropped to 71,910 tons, the pre-1966 level, reflecting resumption and some expansion of domestic production. Mexico provided 70 per cent of total imports, the remainder coming from Britain, Spain and the United States.

Prior to 1957, much of Canadian production was exported to the United States and Europe. In 1958 exports declined abruptly owing to the development of alternative low-cost deposits in Mexico by large consumers in the United States.

World review

Rapid growth in fluorspar consumption by the steel, chemical and aluminum industries coupled with a stagnant ore reserve situation during the 1960's raised fears of a shortage towards the end of the decade. Under the impetus of tightening supply and rising prices, intensive exploration efforts in various parts of the world were successful in substantially augmenting reserves. Expanded and new facilities were brought on stream to meet the expected strong demand. However, coincident with the surge in production came a slackening in demand due to an economic slow down in the major consuming nations, notably the United States and Japan, and during the latter part of 1971 and the first half of 1972 an oversupply situation developed in many areas.

Mexico continued to rank as the world's largest supplier although production dropped 8 per cent from the 1971 tonnage to 1.18 million short tons in 1972. Fluorspar mining began in Mexico in the early 1920's. However, the industry received its greatest stimulus during World War II when the United States government, cut off from European sources, encouraged exploration and development in Mexico. Most production is mined in the State of San Luis Potosí in the Zaragoza area where two major producing mines are located within a mile. The largest, accounting for some 40 per cent of total Mexican metallurgical-grade output is the Las Cuevas mine. This underground operation is an affiliate of Noranda Mines Limited.

Table 3. World fluorspar production, 1970-72

	1970	1971	1972^e
	(short tons)		
Mexico	1,078,594	1,301,779	1,350,000
U.S.S.R.	450,000	460,000	..
Spain	376,621	440,785	..
Thailand	350,785	471,015	..
France	320,000	330,000	..
Italy	318,861	320,810	..
People's Republic of China	300,000	280,000	..
United States	269,221	272,071	260,000
Britain	213,044	269,920	..
Republic of South Africa	190,693	263,497	..
Canada	136,800	85,000^e	160,000
Other countries	592,389	622,488	3,410,000
Total	4,597,008	5,117,365	5,180,000

Source: U.S. Bureau of Mines *Minerals Yearbook*, Preprint 1971, and U.S. Commodity Data Summaries, January 1973.
.. Not available; ^{e}Estimates.

Other companies operating in Canada that have deposits in Mexico include Allied Chemical Corporation and Alcan. The rapid growth of fluorspar production in Mexico from 474,000 tons in 1963 to an estimated 1.30 million tons in 1971 has paralleled consumption increases in the United States which relies upon Mexico for most of its import requirements.

In 1971, four companies announced plans for building hydrofluoric acid plants in Mexico totalling over 200,000 tons a year of acid capacity.

The United States is the world's largest consumer and is heavily reliant on imports to meet demand. In 1972 production was an estimated 240,000 tons, down 4 per cent from 1971, and imports from Mexico were 800,000 tons. Most output in the United States comes from the Illinois-Kentucky district and is produced by two companies, Ozark-Mahoning Company and Minerva Oil Company. Both companies are opening new deposits in Illinois and a new mine and mill development of Cerro Corporation near Salem, Kentucky was under construction during the year. Two mines in the district closed during 1972. Other states producing fluorspar are: Montana, Colorado, Idaho, Arizona, New Mexico and Utah. Lost River Mining Corporation Limited continued feasibility studies and exploration of its extensive deposits near Teller, Alaska.

In France, expansion of the industry continues with several new mining and milling developments under way. New deposits are being worked in central France and in the Massif Central and Alpine regions. Estimated production in 1972 was 405,000 short tons.

In 1972, Spain produced an estimated 380,000 short tons. Significant new reserves have been found in the Caravia district in Oviedo Province. Much of Spanish production is exported, mostly to the United States and West Germany.

Production in Britain expanded considerably during 1971 with the commissioning of the new Hopton works of C.E. Guilini (Derbyshire) Limited and other developments. Output is estimated to have exceeded 300,000 tons in 1972.

Expansions and new development in mining and milling in Italy, principally in Sardinia, have substantially increased the country's output. In 1972, production topped 350,000 short tons.

The U.S.S.R. is the world's second largest producer of fluorspar and, with other states in the Soviet bloc, produced about 650,000 tons in 1972. Domestic supply has fallen short of requirements for some years and imports in 1972 exceeded 200,000 tons. The People's Republic of China and North Korea together produce approximately 300,000 tons per year.

One of the fastest developing new sources of fluorspar in the world is Thailand. Although shipments dropped sharply from the record 346,782 tons in 1971 to 250,000 tons in 1972 due to cutbacks in imports by Japan, shipments for 1973 should surpass 350,000 tons.

Reserves are reportedly 12 million tons of 60 per cent CaF_2. Large reserves indicated in the upper reaches of the River Kwai are currently being explored. Limiting factors on production and market development include primitive mining and beneficiating techniques, and costly and difficult transportation from producing areas to points of export. Loading facilities at Bangkok also present a bottleneck to efficient ocean transport. The Thai government has taken an active interest in the industry and is moving to eliminate these drawbacks.

South Africa's output has more than doubled since 1968 and continues to grow. Production in 1972 was an estimated 260,000 tons. South America until recently produced limited quantities of hand-sorted metallurgical grade. Exploration and development is moving along rapidly in both Brazil and Argentina and large increases in output are anticipated within the next few years.

Outlook

The performance of the fluorspar industry necessarily parallels developments in the steel, chemical and aluminum industries, which together account for 95 per cent of fluorspar consumption.

Conversion from the open hearth process to the basic oxygen process for steelmaking and vigorous growth in the chemical and aluminum industries during the 1960's markedly accelerated fluorspar consumption. A hiatus in this growth during 1971 and much of 1972 obviated a tight supply situation and both consumer and producer stocks, particularly of acid grade, grew substantially.

Exploration efforts resulted in a welcome expansion of world fluorspar reserves to about 320 million tons averaging 30 per cent CaF_2, more than double the known reserves of 1970. However, recovery of the consuming industries from the 1971 slowdown and their projected growth indicates that these reserves are adequate for less than 15 years.

Steel production increased 7 per cent in 1972, and first-quarter statistics for 1973 indicate a phenomenal 15 to 20 per cent further increase for the year to 720 million metric tons. Expected output for 1980 is over 1 billion metric tons. The fluorine chemical industry also appears to be resuming its healthy growth rate of 10-12 per cent a year. After a year of overcapacity and low prices aluminum had recovered by the end of 1972 and a growth rate of 8-9 per cent has been projected over the next few years. However, consumption of fluorspar in the aluminum industry is expected to level off over the medium term as fluorine emissions from potlines are reduced and greater efficiency in recycling is achieved. Also, recovery of fluorine from phosphate rock processing has begun and is currently being utilized in a small way in synthetic cryolite making. In January 1973, Aluminum Company of America (Alcoa) announced a new aluminum-making technique which uses no fluorspar.

It is claimed that power consumption is reduced by 30 per cent, and capital and operating costs are markedly lower than with the present Hall-Héroult process. General adoption of the process, should it prove viable, would probably not occur on a large scale until after 1980. In any case, only 15 per cent of fluorspar consumption is accounted for by the aluminum industry.

World consumption of fluorspar is expected to surpass 7 million tons by 1975 and 10 million tons by 1980, a growth rate of 6-7 per cent a year.

Prices

United States fluorspar prices, quoted in Engineering and Mining Journal of December 1972

(net ton fob Illinois and Kentucky, CaF_2 content, bulk)

	($)
Ceramic, calcite and silica variable, CaF_2	
88-90%	77
95-96%	76.50-82
97%	87
In 100-lb paper bags, extra	6
Metallurgical, pellets, 70%, effective CaF_2	68.50
Acid, dry basis, 97% CaF_2	
Carloads	78.50-87
Less than carloads	78.50-98
Bags, extra	6
Pellets, 88% effective	76.50
Wet filter cake, 8-10% moisture, sold dry content – subtract approx.	2.50
Dry acid concentrates fob Wilmington, 97% CaF_2 st	97.50
European wet filter cake, 8-10% moisture, sold dry content, duty pd., st, cif Wilmington/Philadelphia, term contracts (spot material \$5-10 higher), nominal	81-82
Mexican	
Metallurgical 70% fob cars Mexican border	48.50
Tampico, fob vessel	50.00
Acid, 97%+ Eagle Pass, bulk	62-67

Tariffs

Item No.		
Canada		
29600-1	Fluorspar	free
United States		($/lt)
522.21	Fluorspar, containing over 97% calcium fluoride	2.10
522.24	Fluorspar, containing not over 97% calcium fluoride	8.40

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Gold

J.J. HOGAN

The downward trend in Canadian gold production, which began in 1961, continued in 1972. A further decline is expected in 1973.

Gold production in 1972 was estimated at 2,079,000 fine ounces troy* valued at $119,626,000 based on the average London Free Market gold price of $57.54 for the year. Gold production in 1971 was 2,260,730 ounces valued at $79,903,241 based on the average Royal Canadian Mint price of $35.34.

The largest gold production in Canada for any year was recorded in 1941 when 5,345,179 ounces of gold valued at $205,789,302 were produced. Since World War II, the largest production was reached in 1960 when 4,628,911 ounces valued at $157,151,527 were produced.

Canada has been one of the world's leading producers of gold. Since production was first officially recorded in 1858, Canada has produced 195.8 million ounces to the end of 1972, valued at $6,436 million. Although most provinces have been contributors to the total, Ontario, Quebec, British Columbia, Yukon Territory and the Northwest Territories, in that order, have been the main producers.

World gold production in 1971 was estimated at 46,523,539 million ounces by the U.S. Bureau of Mines compared with 47,530,921 million ounces in 1970. The Republic of South Africa produced 31,388,632 million ounces in 1971. This was 67.5 per cent of the world's production. The U.S.S.R. produced an estimated 6,700,000 million ounces. Canada ranked third in world gold production followed by the United States. Other substantial gold-producing countries were Australia, Ghana, the Philippines and Rhodesia.

Gold production in Canada decreased by 8.0 per cent from 1971. Many factors were responsible for the lower gold production, the main one being the closure of auriferous quartz and base-metal mines during 1971. The sharp rise in the free market gold price enabled some mines to treat lower-grade ore. Also, a shortage of skilled workers at some mines adversely affected production.

In 1972, lode gold mines produced 1,592,000 ounces compared with 1,766,634 in 1971, a decrease of 9.9 per cent. A sharp rise in the free market price of gold made it possible for marginal mines to continue to operate during the year and there were no mine closures. No lode gold mines came into production.

Gold produced from base-metal mining amounted to 483,000 ounces compared with 489,108 in 1971. Gold from this source accounted for 23.2 per cent of the Canadian production compared with 21.6 per cent in 1971.

Ontario continued as the leading gold-producing province in 1972, accounting for 48.5 per cent of the national total. Quebec was in second place with 27.3 per cent followed by the Northwest Territories with 13.9 per cent and British Columbia with 5.8 per cent.

A minor amount of gold was recovered from placer operations, mainly in the Yukon Territory.

Since 1948, a large segment of the gold mining industry has received financial assistance from the Government of Canada under the provisions of the Emergency Gold Mining Assistance Act. Under the terms of the Act, assistance payments were made only for those ounces of gold produced from the mine during a designated period and sold in the form of bullion to the Mint. The price of gold on the free market in 1972 was higher than the official Mint price plus the maximum assistance payable under the Act and therefore the mines sold all the gold produced on the free market. No assistance payments were made for the designated year 1972. The Act was due to expire on June 30, 1973 but the Minister of Energy, Mines and Resources announced that legislation would be introduced to extend the Act for three years to June 30, 1976. This would guarantee a minimum price of about $48 Cdn per ounce of gold to those mines eligible for maximum assistance under the Act.

Operations at producing mines

Atlantic provinces. All gold produced in the Atlantic provinces in 1972 was recovered as a byproduct of base-metal mining. Gold production totalled 17,000 ounces compared with 7,341 in 1971. Production from the new Ming orebody of Consolidated Rambler Mines Limited was largely responsible for the increase in gold production.

Quebec. Gold production in Quebec in 1972 amounted to 567,000 ounces compared with 646,839 in 1971, a decrease of 12.3 per cent. Both the lode gold mines and byproduct base-metal mines recorded a decrease in production. The latter accounted for 33.7

* When used in this review the term 'ounce' refers to troy ounces.

Table 1. Canada, production of gold, 1971-72

	1971	1972p
	(ounces)	
Newfoundland		
Base-metal mines	7,341	17,000
New Brunswick		
Base-metal mines	4,236	3,000
Quebec		
Auriferous quartz mines		
Bourlamaque-Louvicourt	181,504	178,000
Malartic	199,700	198,000
Noranda	21,552	–
Total	402,756	376,000
Base-metal mines	244,083	191,000
Total, Quebec	646,839	567,000
Ontario		
Auriferous quartz mines		
Larder Lake[1]	243,554	228,000
Porcupine[2]	442,559	380,000
Red Lake and Patricia	345,956	320,000
Thunder Bay	15	–
Total	1,032,084	928,000
Base-metal mines	101,903	80,000
Total, Ontario	1,133,987	1,008,000
Manitoba-Saskatchewan		
Base-metal mines	56,023	71,000
Alberta		
Placer operations	79	–
British Columbia		
Auriferous quartz mines	23,546	–
Base-metal mines	65,760	121,000
Placer operations	107	–
Total, British Columbia	89,413	121,000
Yukon		
Base-metal mines	9,671	–
Placer operations	4,802	4,000
Total, Yukon	14,473	4,000
Northwest Territories		
Auriferous quartz mines	308,248	288,000
Base-metal mines	91	–
Total, Northwest Territories	308,339	288,000
Canada		
Auriferous quartz mines	1,766,634	1,592,000
Base-metal mines	489,108	483,000
Placer operations	4,988	4,000
Total	2,260,730	2,079,000
Total value ($)	79,903,241	119,626,000
Average value, per oz ($)	35.34[3]	57.54[4]

Sources: 1971, Statistics Canada; 1972, Statistics Canada and company reports. Breakdown, for both years, by types of operation by Statistics Section, Mineral Resources Branch.
[1]Includes Larder Lake and Kirkland Lake mines and the Ross mine of Hollinger Mines Limited. [2]Does not include the Ross mine of Hollinger Mines Limited. [3]Average Royal Canadian Mint buying price for the year 1971. [4] London Free Market price. Average of a.m. and p.m. fixings for the year 1972 in equivalent Canadian dollars.

per cent of the provincial total as against 37.7 per cent in 1971.

Five gold mines operated in the province in 1972.

Auriferous Quartz Mines. Bourlamaque-Louvicourt district – Two lode gold mines operated in the district in 1972. Production at Lamaque Mining Company Limited was lower than in 1971. Ore reserves at the end of 1971 were limited, but the sharp increase in the free market price of gold during the year enabled the mine to keep operating. Sigma Mines (Quebec) Limited reported a small decrease in gold production. A program to deepen the internal shaft and establish four lower levels was started during the year.

Malartic dictrict – Three lode gold mines operated in this district. Production at Camflo Mines Limited, the largest gold producer in the province in 1972, was just over 100,000 ounces, an increase of about 9 per cent over the previous year. A larger hoist and headframe were purchased to handle the ore more efficiently from the lower levels and will be installed in 1973. The company also reached an agreement to carry out an underground exploration and development program on the adjoining property of Willroy Mines Limited (Norlartic Division). Production at East Malartic Mines, Limited was slightly lower than in 1971. At the end of 1972 Marban Gold Mines Limited had limited ore reserves and was expected to close during 1973. Ore mined was shipped to the custom mill of Malartic Gold Fields (Quebec) Limited.

Major contributors to byproduct gold production

Table 2. World gold production, 1970-71

	1970	1971^{p}
	(ounces)	
North America		
Canada	2,408,574	2,260,730
United States	1,743,322	1,495,108
Other countries	322,548	282,555
Total	4,474,444	4,038,393
South America		
Colombia	217,965	188,842
Brazil	180,076	157,378
Peru	104,258	98,928
Chile	50,718	64,417
Bolivia	30,603	22,179
Other countries	37,079	34,262
Total	620,699	566,006
Europe		
U.S.S.R.^{e}	6,500,000	6,700,000
Yugoslavia	97,384	115,743
France	62,726	65,000
Other countries	137,656	137,910
Total	6,797,766	7,018,653
Asia		
Philippines	602,715	637,048
Japan	255,759	254,890
Korea	160,000	160,000
India	104,200	118,572
Other countries	140,946	118,702
Total	1,263,620	1,289,212
Africa		
Republic of South Africa	32,164,107	31,388,632
Ghana	703,858	697,517
Rhodesia	500,000	500,000
Zaïre	177,128	179,079
Other countries	65,157	53,531
Total	33,610,250	32,818,759
Oceania		
Australia	624,985	670,136
Fiji	103,785	89,129
New Guinea	23,798	23,389
Other countries	11,574	9,862
Total	764,142	792,516
World total	47,530,921	46,523,539

Sources: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1971, and for Canada, Statistics Canada.
^{p}Preliminary; ^{e}Estimated.

were copper ores from the Chibougamau and Noranda districts. Gold production from this source decreased by 21.7 per cent from 1971. The closure of the Quemont and Delbridge mines during the latter part of 1971 and a strike at Campbell Chibougamau Mines Ltd. were responsible for the sharp reduction in gold production.

Ontario. Gold production in Ontario was estimated at 1,008,000 ounces compared with 1,133,987 in 1971. Gold produced from lode mines accounted for 92.1 per cent of the provincial total. Lode gold production decreased by 10.1 per cent from 1971.

Auriferous Quartz Mines. Eleven gold mines operated in the province in 1972.

Larder Lake mining division – This division conforms with the mining divisions as established by the Ministry of Natural Resources, Mines Division. It includes mines shown in the past reviews under Kirkland Lake and Larder Lake and the Ross mine of Hollinger Mines Limited. The Ross mine was formerly grouped with mines in the Porcupine district.

Three mines operated in this mining division in 1972. Gold production at the Ross mine was slightly lower than in 1971. Although ore reserves were limited the increase in the price of gold made it possible to carry out additional development work which added to reserves. Gold production at Kerr Addison Mines Limited was slightly lower than in 1971. Upper Canada Resources Limited has management control of the Macassa Mine of Willroy Mines Limited. Production increased substantially because a larger tonnage of better-grade ore was treated. The ground leased by Willroy from Tegren Goldfields Limited was an important part of the operation.

Porcupine mining division – There were four operating lode gold mines in this district in 1972. On November 17, 1972 Pamour Porcupine Mines, Limited purchased Aunor Gold Mines Limited in order to improve the efficiencies of the two operations. Aunor ore will be trucked to the Pamour mill for treatment. Pamour was expanding mill capacity from about 1,900 tons a day to 2,500 tons to handle the extra tonnage. This program should be completed in the early part of 1973. Gold production at Aunor was lower in 1972 than in 1971. Milling operations at the Pamour No. 2 mine (the former Hallnor Mines, Limited) were terminated in February 1972 although mining continued throughout the year with the ore being trucked to Pamour No. 1 mill for treatment. A shortage of experienced workers and the treatment of reduced tonnage at lower grade than in 1971 resulted in a decline in gold produced by Dome Mines Limited. To partly offset increasing costs of production Dome continued its program of stope mechanization. Operations of the gold and copper sectors at McIntyre Porcupine Mines Limited paralleled those of the previous year. Total gold production was slightly lower than 1971.

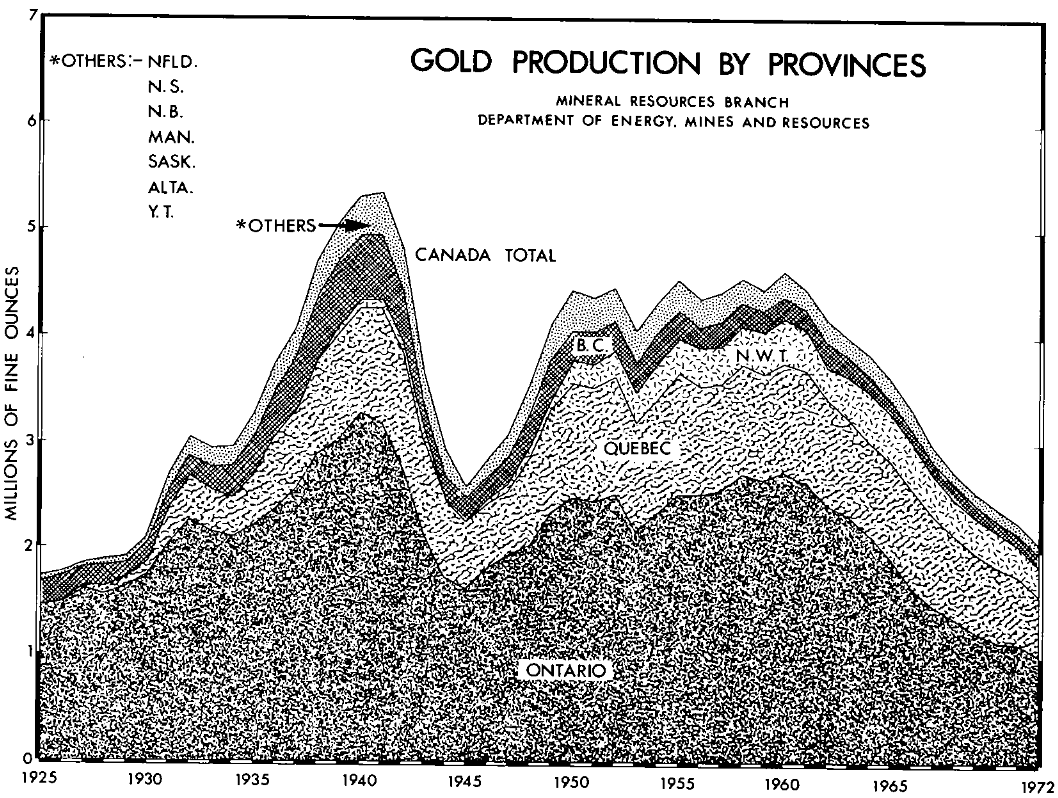
Table 3. Canada, gold production, 1963-72

	Auriferous Quartz Mines		Placer Operations		Base-metal Ores		Total	
	(oz)	(%)	(oz)	(%)	(oz)	(%)	(oz)	(%)
1963	3,324,907	83.1	57,905	1.4	620,315	15.5	4,003,127	100
1964	3,151,593	82.2	58,512	1.5	625,349	16.3	3,835,454	100
1965	2,958,874	82.1	44,598	1.2	602,559	16.7	3,606,031	100
1966	2,676,381	80.6	43,369	1.3	599,724	18.1	3,319,474	100
1967	2,426,137	81.2	9,411	0.3	550,720	18.5	2,986,268	100
1968	2,208,184	80.5	9,564	0.4	525,273	19.1	2,743,021	100
1969	2,030,680	79.8	8,725	0.3	505,704	19.9	2,545,109	100
1970	1,883,764	78.2	7,359	0.3	517,451	21.5	2,408,574	100
1971	1,766,634	78.2	4,988	0.2	489,108	21.6	2,260,730	100
1972[p]	1,592,000	76.6	4,000	0.2	483,000	23.2	2,079,000	100

Sources: Statistics Canada; breakdown classification by Statistics Section, Mineral Resources Branch.
[p]Preliminary.

Red Lake mining division – Four lode gold mines operated in this district in 1972.

Campbell Red Lake Mines Limited, the largest gold producer in Canada, announced that it will spend approximately $1 million for alterations to the roasting plant to reduce gaseous and particulate emissions. Gold production in 1972 was about the same as in 1971. The treatment of lower-grade ore at a slightly reduced tonnage at Dickenson Mines Limited resulted in a decrease in gold production in 1972.



Dickenson mined the ore from the property of Robin Red Lake Mines Limited through extensions of the underground workings to its adjoining property, and custom treated the ore. In 1972 the highest-grade ore in Canada, just under one ounce per ton, was mined at Robin Red Lake. Tonnage treated averaged about 100 tons a day. Production at Madsen Red Lake Gold Mines Limited decreased in 1972 with lower-grade ore at reduced tonnage being mined. The mine was able to continue operations because of the higher price received for gold.

Base-metal Mines. Byproduct gold played a minor role in gold production in Ontario. It was recovered from the nickel-copper ores of the Sudbury and the copper-zinc ores at Manitouwadge. McIntyre, in Timmins, recovered appreciable amounts of gold from the copper sector of the operation. The copper mine of Upper Beaver Mines Limited in the Kirkland Lake area closed early in 1972. This property produced a substantial amount of byproduct gold.

Prairie Provinces. Virtually all gold produced in the Prairie Provinces was recovered as a byproduct from the mining of base-metal ores. Production in 1972 was estimated at 71,000 ounces compared with 56,023 in 1971. The settlement of a strike at the Flin Flon and Snow Lake plants of Hudson Bay Mining and Smelting Co., Limited in Manitoba was largely responsible for the increase in production. Sherritt Gordon Mines, Limited recovered gold from its copper-zinc operation in the Lynn Lake district. Some byproduct gold was recovered from the nickel-copper ores of The International Nickel Company of Canada, Limited at Thompson. The copper mine of Anglo-Rouyn Mines Limited, near Lac La Ronge in Saskatchewan, closed in August. This mine was a substantial contributor to byproduct gold production. A minor amount of gold was recovered by gravel washing plants on the North Saskatchewan River near Edmonton.

British Columbia. With the exception of a minor amount of gold recovered from the placer deposits in the central part of the province and in the Atlin district, all gold produced in British Columbia in 1972 was recovered as a byproduct of base-metal mines, mainly from the treatment of copper ores. Total byproduct gold production was 121,000 ounces compared with 65,760 in 1971. Copper producers coming into production the latter part of 1971 and in 1972 were responsible for the sharp increase in gold production. Byproduct gold production should show a further increase in 1973. The Island Copper mine of Utah Mines Ltd., the Phoenix Copper Division of The Granby Mining Company Limited, Granisle Copper Limited, Similkameen Mining Company Limited and Western Mines Limited were the main producers of byproduct gold. Coast Copper Company, Limited, a contributor of byproduct gold production, closed in November.

Yukon Territory. The Yukon reported a sharp decrease in gold production in 1972. Whitehorse Copper Mines Ltd. completed an underground development program and resumed operations in December. This property has produced an appreciable amount of byproduct gold.

Placer gold was produced by small operators in the Dawson, Mayo and Kluane Lake districts.

Northwest Territories. Five gold mines, all located near the town of Yellowknife, were in production in 1972, but production was lower than in 1971. The Con mine of Cominco Ltd. treated ore from its own property and the adjoining property of Rycon Mines Limited. The results of diamond drilling on the lower levels were such that Cominco was studying the economics of recovering this ore, including the sinking of a new surface shaft. Giant Yellowknife Mines Limited mined and milled ore from its own property and from the adjoining properties of Lolor Mines Limited and Supercrest Mines Limited. The rise in the free market price of gold permitted Giant to treat lower-grade ore and to improve its ore reserve position.

New property developments

Agnico-Eagle Mines Limited was proceeding with mill construction and the installation of machinery at its property in Joutel Township, northwestern Quebec and has planned to have the property ready for production during the latter part of 1973.

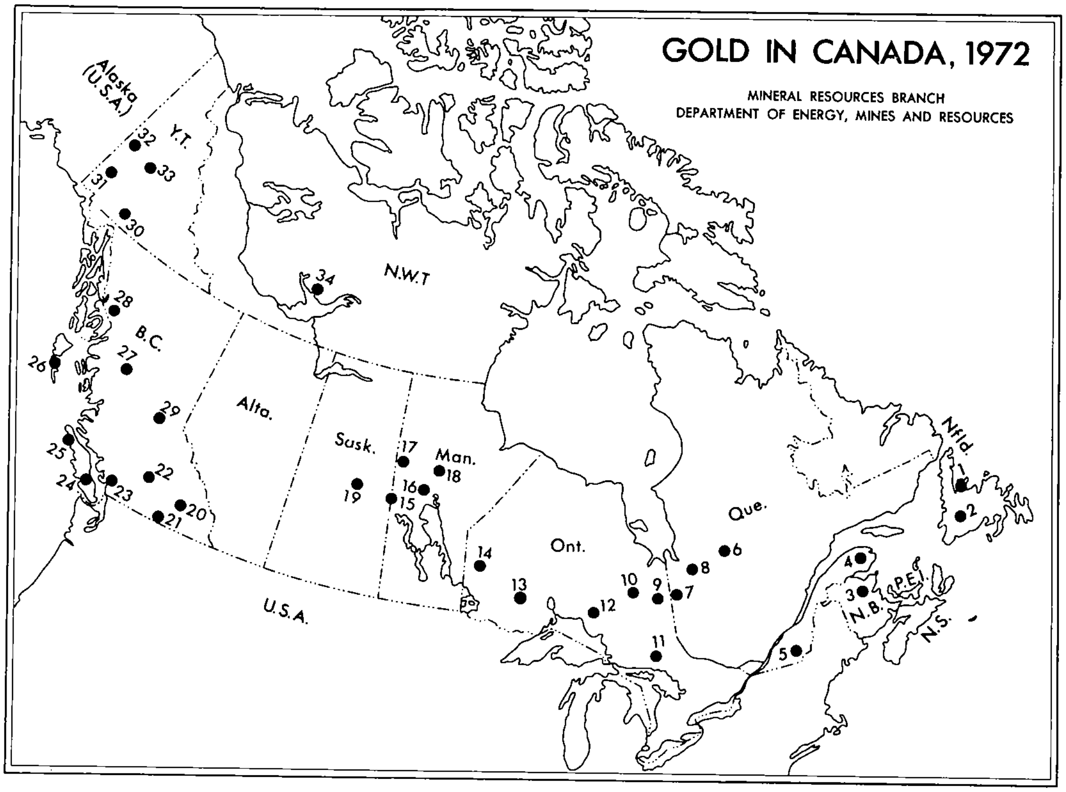
Exploratory work was carried out on some gold prospects but generally the increase in the free market gold price was not sufficient to create any great activity in gold exploration.

Prices

Problems relating to uncertainties in the world monetary arrangements led to a sharp rise in the price of gold on the open market. The Republic of South Africa offered reduced quantities of gold to the world markets and this added to the pressures forcing an upward trend in the price. The gold price on the London market opened in 1972 at a low of U.S. $43.725 an ounce and progressively increased until it reached a high of U.S. $70 on August 2. The price declined from this peak to a range of U.S. $61-65 for the last three months of the year.

The finance ministers of the Group of Ten met at the Smithsonian Institution, Washington, D.C. and on December 18, 1971 reached an agreement on the realignment of their currencies. The United States agreed to devalue its currency by 7.89* per cent,

* On Feb. 12, 1973 the U.S. announced its intention to devalue the dollar by 10 per cent. The price of gold would be raised from $38 an ounce to $42.22.



Gold producers, 1972

(numbers refer to numbers on the map)

Newfoundland
1. Consolidated Rambler Mines Limited (*a*)
2. American Smelting and Refining Company (Buchans Unit) (*a*)

New Brunswick
3. Heath Steele Mines Limited (*a*)

Quebec
4. Gaspé Copper Mines, Limited (*a*)
5. Sullivan Mining Group Ltd. (*a*)
6. Chibougamau district
   Campbell Chibougamau Mines Ltd. (*a*)
   Falconbridge Copper Limited (Opemiska Division) (*a*)
   Patino Mines (Quebec) Limited (Copper Rand Division) (*a*)
7. Noranda-Rouyn district
   Falconbridge Copper Limited (Lake Dufault Division) (*a*)
   Noranda Mines Limited (*a*)
   Malartic district
   Camflo Mines Limited (*b*)
   East Malartic Mines, Limited (*b*)
   Marban Gold Mines Limited (*b*)
   Bourlamaque-Louvicourt district
   Lamaque Mining Company Limited (*b*)
   Manitou-Barvue Mines Limited (*a*)
   Sigma Mines (Quebec) Limited (*b*)
   Duparquet district
   Kerr Addison Mines Limited (Normetal) (*a*)
8. Matagami District
   Mattagami Lake Mines Limited (*a*)
   Orchan Mines Limited (*a*)

Ontario
9. Larder Lake Mining Division
   Hollinger Mines Limited (Ross) (*b*)
   Kerr Addison Mines Limited (*b*)
   Upper Beaver Mines Limited (*b*)
   Willroy Mines Limited (Macassa Division) (*b*)
10. Porcupine Mining Division
   Aunor Gold Mines Limited (*b*)
   Dome Mines Limited (*b*)
   McIntyre Porcupine Mines Limited (*a*) (*b*)
   Pamour Porcupine Mines, Limited (*b*)
11. Sudbury Mining Division
   Falconbridge Nickel Mines Limited (*a*)
   The International Nickel Company of Canada, Limited (*a*)
12. Thunder Bay Mining Division
   Noranda Mines Limited (Geco Mine) (*a*)
13. Patricia Mining Division
   Mattabi Mines Limited (*a*)

14. Red Lake Mining Division
    Campbell Red Lake Mines Limited (*b*)
    Dickenson Mines Limited (*b*)
    Madsen Red Lake Gold Mines Limited (*b*)
    Robin Red Lake Mines Limited (*b*)

Manitoba
15. Hudson Bay Mining and Smelting Co., Limited (*a*)
16. Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (*a*)
17. Sherritt Gordon Mines, Limited (Fox Lake) (*a*)
18. The International Nickel Company of Canada, Limited (Thompson) (*a*)

Saskatchewan
15. Hudson Bay Mining and Smelting Co., Limited (*a*)
19. Anglo-Rouyn Mines Limited (*a*)

British Columbia
20. Cominco Ltd. (*a*)
21. The Grandby Mining Company Limited (Phoenix Copper Division) (*a*)
22. Bethlehem Copper Corporation Ltd. (*a*)
    Brenda Mines Limited (*a*)
    Lornex Mining Corporation Ltd. (*a*)
    Similkameen Mining Company Limited (*a*)
23. Texada Mines Ltd. (*a*)
24. Western Mines Limited (*a*)
25. Coast Copper Company, Limited (*a*)
    Utah Mines Ltd. (Island Copper Mine) (*a*)
26. Wesfrob Mines Limited (*a*)
27. Granisle Copper Limited (*a*)
    Nadina Explorations Limited (Bradina Joint Venture) (*a*)
    Noranda Mines Limited (Bell Copper) (*a*)
28. Granduc Operating Company (*a*)
29. Gibraltar Mines Ltd. (*a*)
    Small placer operations (*c*)

Yukon Territory
30. Whitehorse Copper Mines Ltd. (*a*)
31. Small placer operations (*c*)
32. Small placer operations (*c*)
33. Small placer operations (*c*)

Northwest Territories
34. Cominco Ltd. (Con Mine) (*b*)
    Giant Yellowknife Mines Limited (*b*)
    Lolor Mines Limited (*b*)
    Rycon Mines Limited (*b*)
    Supercrest Mines Limited (*b*)

(*a*) Base metal; (*b*) Auriferous quartz; (*c*) Placer.

subject to approval by Congress, by raising the official price of gold from U.S. $35 an ounce to $38. The agreement was approved by Congress. On May 8, 1972 the International Monetary Fund formally announced the parity of the U.S. dollar. On the same day the price payable for the gold content of a deposit delivered to the Royal Canadian Mint was raised to U.S. $38 an ounce.

The average Mint price paid for gold in 1972 was $36.58 Cdn an ounce compared with $35.34 in 1971 and $36.56 in 1970.

Table 4. Canada, gold production, average value per ounce and relationship to total value of all mineral production, 1963-72

	Total Production	Total Value	Average Value per Ounce	Gold as Percentage of Total Value of Mineral Production
	(oz)	($ Cdn)	($ Cdn)	(%)
1963	4,003,127	151,118,045	37.75	5.0
1964	3,835,454	144,788,388	37.75	4.3
1965	3,606,031	136,051,943	37.73	3.7
1966	3,319,474	125,177,364	37.71	3.1
1967	2,986,268	112,731,618	37.75	2.6
1968	2,743,021	103,439,321	37.71	2.2
1969	2,545,109	95,925,158	37.69	2.0
1970	2,408,574	88,057,464	36.56	1.5
1971	2,260,730	79,903,241	35.34	1.3
1972[p]	2,079,000	119,626,000	57.54[1]	1.2

Source: Statistics Canada.
[p]Preliminary.
[1]See footnote No. 4, Table 1.

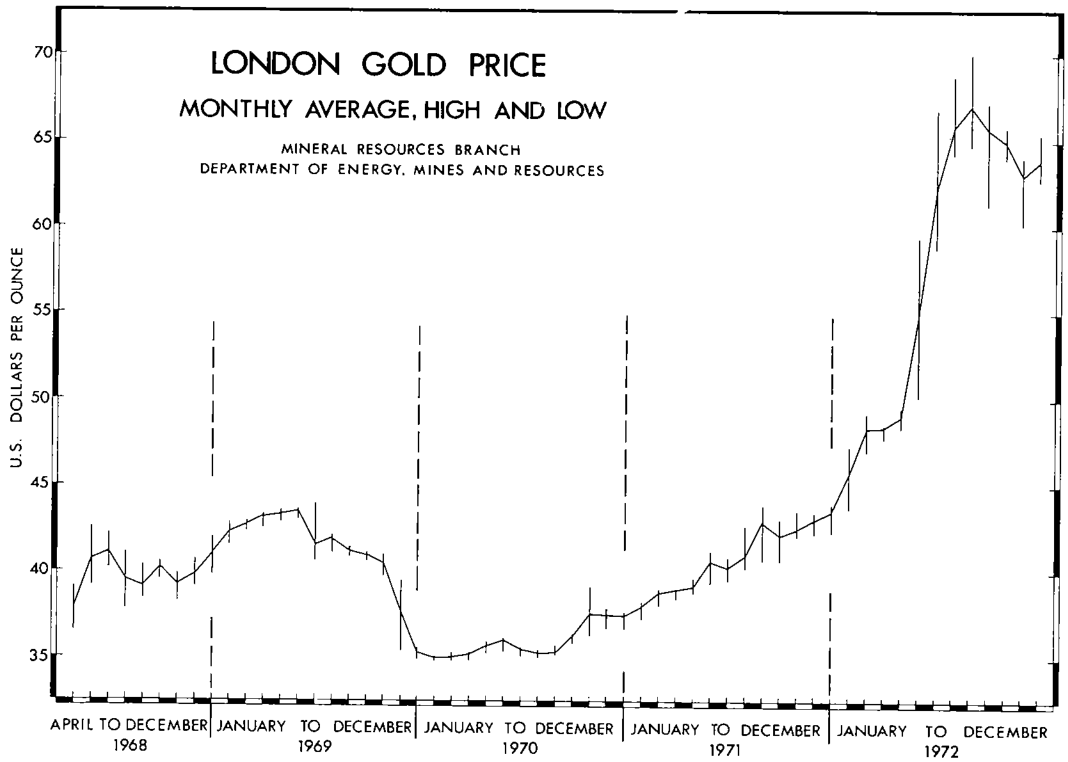
Table 5. Average annual price of gold 1968-72

	London Free Market[1]		Royal Canadian Mint[2]
	($ U.S.)	(equiv. $ Cdn)	($ Cdn)
1968	39.85[3]	42.83[3]	37.71
1969	41.09	44.25	37.69
1970	35.97	37.55	36.56
1971	40.80	41.20	35.34
1972	58.13	57.54	36.58

[1]Annual averages of London Free Market price, calculated from a.m. and p.m. fixings, as reported by Sharp-Pixley Ltd. [2]Annual averages of the Royal Canadian Mint weekly published buying prices. [3]Average for the period April to December 1968 of the a.m. and p.m. fixings of the London Free Market, as quoted by Sharp-Pixley Ltd. London Free Market quotations commenced in April 1968.

Uses

Gold has been used traditionally as a monetary measure by governmental and central banks in the settlement of international balances. With the establishment of the two-tier gold price arrangement, in March 1968, most of the central banks agreed that they would not add or subtract from their official gold



reserve position by purchases or sales of gold on the free market. This was amended later to permit South Africa to dispose of some of its gold to the International Monetary Fund. Since this time all newly mined gold and that held by investors and speculators was available to meet the demands of the open market.

A study made for Consolidated Gold Fields Limited, *Gold 1972*, by Peter D. Fèlls shows that the industrial uses of fabrication of gold in the non-communist countries has increased from 1,271.5 metric tons in 1968 to 1,412.2 tons in 1971.

The jewellery or artistic trade was the largest user of gold and accounted for over 70 per cent of the gold consumed by industry. Dentistry and the electronic industry were other major consumers. Technological developments in the electronic industry, especially in the field of selective gold plating and alloy substitution permitted the manufacturer to reduce the use of gold. Further uses of gold were in the aerospace industry and in medals and medallions.

Gypsum and Anhydrite

D. H. STONEHOUSE

Gypsum is a hydrous calcium sulphate ($CaSO_4 \cdot 2H_2O$) which, when calcined at temperatures ranging from 250° to 400°F, releases three quarters of its chemically combined water. The resulting hemihydrate of calcium sulphate, commonly referred to as plaster of paris, when mixed with water, can be moulded, shaped or spread and subsequently dried, or set to form a hard plaster product. Gypsum is the main mineral constituent in gypsum wallboard, lath and tile. Anhydrite, the anhydrous calcium sulphate ($CaSO_4$), is commonly associated geologically with gypsum.

Crude gypsum is crushed, pulverized and calcined to form stucco, which is mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form interior wall finishes. Gypsum board, lath and sheathing are formed by introducing a slurry of stucco, water, foam, pulp and starch between two sheets of absorbent paper, which results in a continuous 'sandwich' of wet board. As the stucco hardens, the board is cut to predetermined lengths, dried, bundled and stacked for shipment.

Crude gypsum is also used in the manufacture of portland cement where it acts as a retarder, to control set. It is used as a filler in paint and paper manufacture, as a substitute for saltcake in glass manufacture and as a soil conditioner.

Production of gypsum in Canada is closely related to activity in the building construction industry, particularly to activity in the residential building sector, in both Canada and the eastern United States. Over 70 per cent of Canadian gypsum production is exported to the United States. In 1972 Canadian production increased to 7.9 million tons, exports rose to nearly 6.0 million tons and imports, mainly from Mexico to the west coast, were reduced to 62,383 tons. Most of the gypsum for export is quarried in Nova Scotia by Canadian subsidiaries of United States gypsum products manufacturers. While most of the output from other provinces is used regionally, nearly all of the Nova Scotian production is exported in large 'in company' shipments to the eastern United States.

The value of total construction in Canada during 1972 was estimated at $16.3 billion, about 30 per cent of which was recognized as residential construction. Housing starts reached a record 249,914 in 1972, up 7 per cent from the previous year, and showed a marked trend towards single-family dwellings. Production of gypsum wallboard, lath and sheathing increased by 119,633,550 square feet in 1972 and plaster production decreased by 7,139 tons.

Canadian industry and developments

Atlantic provinces. During 1972 five companies produced crude gypsum in Nova Scotia, two in New Brunswick and one in Newfoundland. Regional consumption of raw gypsum was small compared to the quantity exported to the United States from the Atlantic provinces. Three cement manufacturing plants, two gypsum wallboard manufacturing plants and one plant producing plaster of paris, together used only about 100,000 tons. Crude gypsum from Nova Scotia is used by Quebec wallboard plants and by Quebec and Ontario cement producers, each supplying regional construction industries.

Fundy Gypsum Company Limited, a subsidiary of United States Gypsum Company, Chicago, mines gypsum by open-pit methods at Wentworth and at Miller Creek near Windsor, Nova Scotia, for export to the United States. Crushed and beneficiated crude gypsum is shipped to company-owned processing plants through the port of Hantsport, Nova Scotia.

National Gypsum (Canada) Ltd. produces gypsum from a quarry near Milford, Nova Scotia, and exports most of it through the port of Halifax to east coast United States plants operated by the parent company, National Gypsum Company of Buffalo, New York. Unit-trains of 40 cars each are used to haul gypsum from the quarry site 30 miles to Dartmouth. Company-owned, self-unloading ore carriers of up to 30,000 tons capacity are loaded at rates of up to 5,000 tons per hour through facilities on Bedford Basin. Shipments are made also to Quebec for use in the manufacture of gypsum products and cement, and by truck to Brookfield, Nova Scotia for use in cement manufacture.

Georgia-Pacific Corporation, Bestwall Gypsum Division, mines gypsum from a quarry near River Denys, Inverness County, Nova Scotia. Crushed rock is transferred by rail to open storage at Point Tupper, 20 miles from the quarry, and loaded to chartered vessels through a conveyor and reclaim tunnel system. Shipments are exported mainly to the Georgia-Pacific plant at Wilmington, Delaware.

Little Narrows Gypsum Company Limited, another subsidiary of United States Gypsum Company, produces gypsum from a quarry at Little Narrows, Victoria County, Nova Scotia, for shipment to the United States, Quebec and Ontario, through company ship-loading facilities near the plant site. This is the source of raw gypsum for a new wallboard plant made operative in February 1971 by Canadian Gypsum Company, Limited at St-Jérôme, 27 miles northwest of Montreal, Quebec

At Walton, Hants County, Nova Scotia, gypsum and anhydrite are produced for National Gypsum (Canada) Ltd. by B. A. Parsons under contract. Shipments were made through the port of Walton to United States destinations.

Domtar Construction Materials Ltd. operates a calcining plant at Windsor, Nova Scotia, for the production of plaster of paris. Gypsum for the plant is supplied from a quarry at MacKay Settlement, under contract with D. MacDonald.

Table 1. Canada, gypsum production and trade, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Crude gypsum				
Nova Scotia	4,889,786	10,341,880	5,990,000	13,088,000
Newfoundland	560,703	1,666,067	600,000	1,746,000
Ontario	699,041	1,656,421	664,000	1,450,000
British Columbia	344,795	930,348	433,000	1,190,000
Manitoba	130,297	228,684	180,000	346,000
New Brunswick	77,478	259,300	75,000	250,000
Total	6,702,100	15,082,700	7,942,000	18,070,000
Imports				
Crude gypsum				
Mexico	102,700	390,000	55,000	179,000
United States	3,060	37,000	7,264	84,000
Other countries	23	2,000	119	4,000
Total	105,783	429,000	62,383	267,000
Plaster of paris and wall plaster				
United States	10,273	661,000	15,863	939,000
Britain	282	13,000	363	17,000
Other countries	16	2,000	16	2,000
Total	10,571	676,000	16,242	958,000
Gypsum lath, wallboard and basic products	(sq. ft.)		(sq. ft.)	
United States	39,671,465	1,427,000	48,779,016	1,691,000
Britain	88,016	4,000	366,513	23,000
Total	39,759,481	1,431,000	49,145,529	1,714,000
Total imports, gypsum and gypsum products		2,536,000		2,939,000
Exports				
Crude gypsum				
United States	4,959,638	9,572,000	5,914,998	12,221,000
Bahamas	75,336	113,000	47,975	72,000
Total	5,034,974	9,685,000	5,962,973	12,293,000

Source: Statistics Canada.
^{p} Preliminary; – Nil.

Many other gypsum occurrences are known in the central and northern mainland of Nova Scotia and on Cape Breton Island.

Gypsum is mined at Flat Bay Station, Newfoundland, 60 miles southwest of Corner Brook, by The Flintkote Company of Canada Limited, mostly for export to company plants in the United States. Raw gypsum is supplied to the Corner Brook plant of Atlantic Gypsum Limited for the manufacture of gypsum wallboard products and plaster of paris, and to the cement plant operated by North Star Cement Limited, also at Corner Brook. Exports are made through the port of St. George's from an open stockpile supplied by an aerial cable tramway carrying rock from Flat Bay, 6 miles from the shipping site. Other gypsum occurrences are known in the southwestern lowlands, west of the Long Range Mountains.

In New Brunswick, two companies quarry gypsum. Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, produces gypsum for use in the manufacture of plaster and wallboard in the company-owned plant at Hillsborough. Canada Cement Lafarge Ltd. obtains gypsum from the Havelock area, west of Moncton, for use in the manufacture of portland cement at Havelock.

Other gypsum occurrences in the southeastern counties of New Brunswick have been recorded. On the Magdalen Islands in Quebec many gypsum outcrops occur.

Ontario. Two underground gypsum mines are operated in southwestern Ontario to produce raw material for three gypsum products plants and a number of cement manufacturing plants. Domtar Construction Materials Ltd. mines gypsum at Caledonia, near Hamilton, from an 8-foot seam 75 feet below the surface. Crude gypsum is shipped to other consumers as well as being supplied to the company's wallboard plant at the mine site, where a full range of gypsum building products was manufactured.

At Hagersville, southwest of Caledonia, Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, Chicago, produces crude gypsum by room and pillar mining methods from a 4-foot seam, reached through a 95-foot vertical shaft. Gypsum rock is shipped in crude form and is used also by the company in the production of wallboard and plaster in a plant adjacent to the mine shaft. The production capacity of the gypsum products plant was increased in 1969 by doubling the output potential of one wallboard line.

Gypsum has been proven at depths down to 200 feet in other parts of southwestern Ontario and under 10 to 30 feet of overburden in the Moose River area south of James Bay.

Western provinces. Crude gypsum is produced from one underground mine and one surface operation in Manitoba and from one surface operation in British Columbia. Gypsum products plants, situated in areas exhibiting major development trends are supplied from Canadian producers of gypsum rock. Imports, mostly from Mexico, supply a number of cement producers.

Domtar Construction Materials Ltd. obtains crude gypsum from its quarry at Gypsumville, 150 miles northwest of Winnipeg, Manitoba. The company's gypsum products plant at Winnipeg uses crude from this source as well as gypsum from Silver Plains mined by Westroc Industries Limited.

Westroc Industries Limited mines gypsum from a deposit 140 feet beneath the surface near Silver Plains, 30 miles south of Winnipeg. Crushed and screened product is used by the company's gypsum products plant in Winnipeg and quantities are shipped to BACM Industries Limited's gypsum products plant at Saskatoon as well as to cement manufacturers in Winnipeg, Regina and Saskatoon.

Western Gypsum Mines Ltd., a subsidiary of Westroc Industries Limited, operates an open-pit mine near Windermere in the southeastern part of British Columbia, supplying raw gypsum to its products plants at Calgary and Vancouver, to the Calgary and Vancouver plants of Domtar Construction Materials Ltd., to the Edmonton plant of BACM Industries Limited and to cement manufacturers in the Vancouver area, Kamloops, Exshaw and Edmonton. Crude gypsum from Windermere is exported to cement manufacturers in northeastern United States.

Gypsum occurs in Wood Buffalo National Park, in Jasper National Park, along the Peace River between Peace Point and Little Rapids, and north of Fort Fitzgerald in Alberta; on Featherstonhaugh Creek, near Mayook, Canal Flats, Loos, and Falkland in British Columbia; on the shores of Great Slave Lake, the Mackenzie, Great Bear and Slave rivers in the Northwest Territories and on several Arctic islands.

World review

Gypsum occurs in abundance throughout the world but because its use is dependent on the building construction industry, developments are generally limited to the industrialized countries. Reserves are generally considered 'adequate'.

The United States is the world's largest single producer and together with Canada brings North American production to near 30 per cent of world output. Asian producers account for about 12 per cent of the world total, the three major producers being Iran, India and Japan. Central America, South America, Africa and Oceania each produce significant amounts with Mexico contributing by far the greatest tonnage of any country in this group.

Interest in byproduct gypsum continued as companies explored the economics of producing wallboard, plaster and plaster-based blocks from the waste gypsum that results during the manufacture of phos-

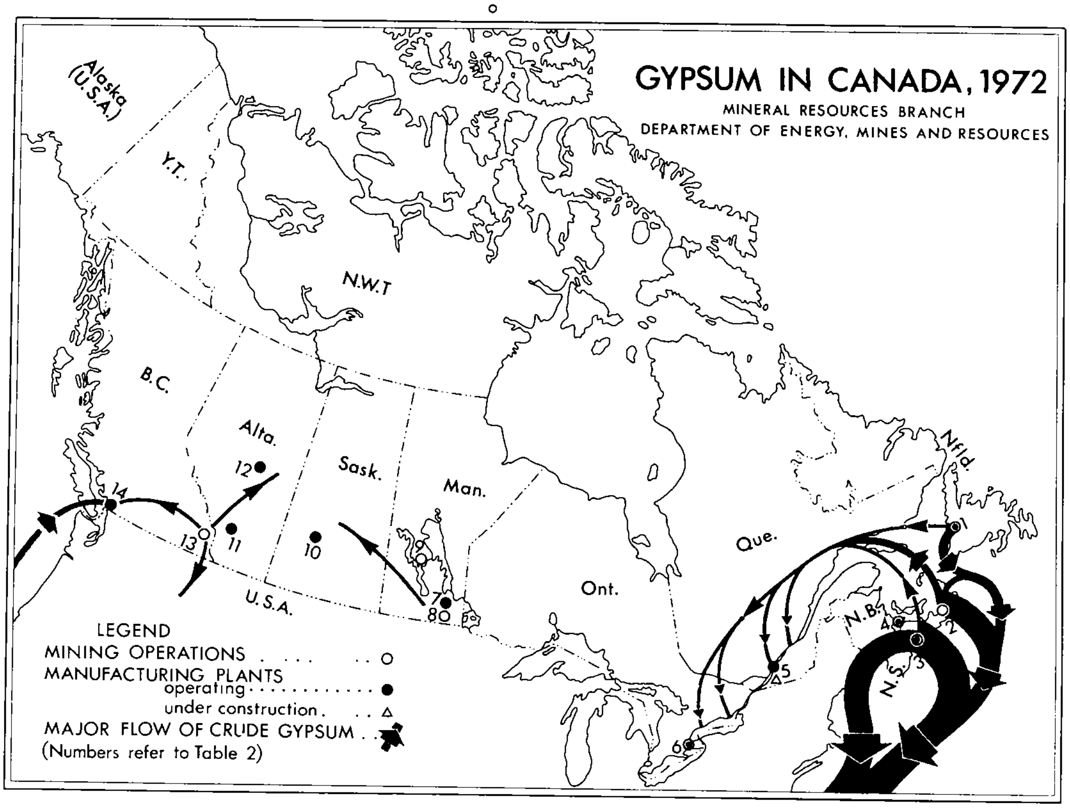


Table 2. Canada, summary of gypsum and gypsum products operation, 1972
(numbers refer to map)

Company	Location	Remarks
Newfoundland		
1. The Flintkote Company of Canada Limited	Flat Bay	Open-pit mining of gypsum
Atlantic Gypsum Limited	Corner Brook	Gypsum products manufacture
Nova Scotia		
2. Little Narrows Gypsum Company Limited	Little Narrows	Open-pit mining of gypsum and anhydrite
Georgia-Pacific Corporation Bestwall Gypsum Division	River Denys	Open-pit mining of gypsum
3. Fundy Gypsum Company Limited	Wentworth and Miller Creek	Open-pit mining of gypsum and anhydrite
National Gypsum (Canada) Ltd.	Milford	Open-pit mining of gypsum
	Walton	Open-pit mining of gypsum and anhydrite
Domtar Construction Materials Ltd.	Mackay Settlement	Open-pit mining of gypsum
	Windsor	Gypsum plaster manufacture

Company	Location	Remarks
New Brunswick		
4. Canadian Gypsum Company, Limited	Hillsborough	Open-pit mining of gypsum and gypsum products manufacture
Canada Cement Lafarge Ltd.	Havelock	Open-pit mining of gypsum used in cement manufacture
Quebec		
5. Canadian Gypsum Company, Limited	Montreal	Gypsum products manufacture
Canadian Gypsum Company, Limited	St-Jérôme	Gypsum products manufacture
Domtar Construction Materials Ltd.	Montreal	Gypsum products manufacture
Westroc Industries Limited	Ste-Cathérine d'Alexandrie	Gypsum products manufacture
Ontario		
6. Canadian Gypsum Company, Limited	Hagersville	Underground mining of gypsum and gypsum products manufacture
Domtar Construction Materials Ltd.	Caledonia	Underground mining of gypsum and gypsum products manufacture
Westroc Industries Limited	Clarkson	Gypsum products manufacture
Manitoba		
7. Domtar Construction Materials Ltd.	Winnipeg	Gypsum products manufacture
Westroc Industries Limited	Winnipeg	Gypsum products manufacture
8. Westroc Industries Limited	Silver Plains	Underground mining of gypsum
9. Domtar Construction Materials Ltd.	Gypsumville	Open-pit mining of gypsum
Saskatchewan		
10. BACM Industries Limited	Saskatoon	Gypsum products manufacture
Alberta		
11. Domtar Construction Materials Ltd.	Calgary	Gypsum products manufacture
Westroc Industries Limited	Calgary	Gypsum products manufacture
12. BACM Industries Limited	Edmonton	Gypsum products manufacture
British Columbia		
13. Western Gypsum Mines Ltd.	Windermere	Open-pit mining of gypsum
14. Westroc Industries Limited	Vancouver	Gypsum products manufacture
Domtar Construction Materials Ltd.	Vancouver	Gypsum products manufacture

phoric acid from phosphate rock. Sabina Industries Limited holds the Canadian and United States rights to a patented process (the Giulini process) for the recovery of high-quality gypsum from this type of waste product. In Canada two subsidiaries of Imperial Oil Limited – Esso Chemical Canada and Building Products of Canada Limited – investigated the process during 1972. Gable Industries Ltd., Atlanta, Georgia negotiated during 1971 to sublicense the process in the United States. The company's option was not extended by Sabina through 1972.

Production of sulphuric acid and coproduct cement from gypsum and anhydrite has been practised in European countries for a number of years.

Table 3. World production of gypsum, 1971-72

	1971	1972[e]
	(thousand short tons)	
United States	10,418	11,702
Canada	6,702	7,942
France	5,634	7,000
Britain	4,600	5,000
Italy	3,860	4,000
Other noncommunist	19,421	18,000
Communist countries (except Yugoslavia)	7,828	8,000
World total	58,463	61,644

Source: United States Bureau of Mines, Commodity Data Summaries, January 1973; and for Canada, Statistics Canada.
[e] Estimated.

Markets, trade and outlook

Gypsum products are not shipped great distances because freight and handling costs represent a major part of the price to the consumer for items that are relatively low-priced and readily available at many locations in Canada. Although gypsum products are usually manufactured close to the consumer, with modern containerized shipments becoming more popular and with the trend to trade off economic and environmental factors, the establishment of wallboard plants at the raw material source could become attractive. The long-established gypsum industry in Nova Scotia exists because efficient, large-volume, transportation facilities and favourable mining conditions and costs enable successful competition with inland United States operations. Canadian exports of crude gypsum are mainly to the eastern United States and are dependent on the building construction industry there. On the basis of projected percentage increases in the gross national product of the United States, exports of gypsum from Nova Scotia are expected to reach 6.5 million tons by 1975 and 9 million tons by 1980. Cumulative United States domestic demand for crude gypsum to the year 2000 has been estimated at 680 million tons.

Some raw gypsum is moved from the Atlantic provinces to Montreal and Toronto regions for use in gypsum products manufacture and in cement production. Raw gypsum is rail-hauled from near Winnipeg, Manitoba to Calgary, Alberta and to Saskatoon, Saskatchewan, and from Windermere, British Columbia to Calgary, Edmonton and Vancouver for gypsum products manufacture. Raw gypsum is imported on the west coast from Mexico, mainly for cement manufacture. Minor amounts of crude gypsum are shipped to the mid-United States for agricultural use, and quantities are exported to the northwestern United States from British Columbia, mainly for use by cement manufacturers.

Table 4. Canada, gypsum production, trade and consumption, 1963-72

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
		(short tons)		
1963	5,955,266	74,628	4,703,118	1,326,776
1964	6,360,685	80,940	5,057,253	1,384,372
1965	6,305,629	75,433	4,746,628	1,634,424
1966	5,976,164	85,913	4,672,518	1,389,559
1967	5,175,384	69,112	3,896,134	1,348,362
1968	5,926,940	69,062	4,463,605	1,532,397
1969	6,373,648	81,799	4,871,184	1,584,263
1970	6,318,523	38,880	4,853,304	1,504,099
1971	6,702,100	105,783	5,034,974	1,772,909
1972[p]	7,942,000	62,383	5,962,973	2,041,410

Source: Statistics Canada.
[1] Producers' shipments, crude gypsum. [2] Includes crude and ground, but not calcined. [3] Production plus imports minus exports.
[p] Preliminary.

Table 5. Canada, production of gypsum products, 1971-72

	1971	1972
	(square feet)	
Wallboard	1,077,065,996	1,198,962,046
Lath	119,733,396	109,453,464
Sheathing	31,471,782	39,489,214
	(short tons)	
Plaster	139,534	132,395

Source: Statistics Canada.

Construction expenditures in both Canada and the United States are expected to increase at 3 to 5 per cent a year. Construction of homes, apartments, schools and offices will continue and the need for gypsum-based building products will rise steadily. Although new construction materials are being introduced, gypsum wallboard will remain popular because of price and ease of installation. The present structure of the gypsum industry in Canada is unlikely to change greatly in the near future. Building materials plants have sufficient capacities to meet the short-term, regional demand for products and the ability to adapt to new building techniques. Canadian Standards Association standards A82.20 to A82.35 relate to gypsum and gypsum products.

ANHYDRITE

Production and trade statistics for anhydrite are included with gypsum statistics. Anhydrite is produced by Fundy Gypsum Company Limited at Wentworth, Nova Scotia, by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia and for National Gypsum (Canada) Ltd. by B. A. Parsons at Walton, Nova Scotia. According to the Nova Scotia *Annual Report on Mines*, production of anhydrite in 1971 was 312,826 tons. Most of this was shipped to the United States for use in portland cement manufacture and as a peanut crop fertilizer. Cement plants in Quebec and Ontario also used some Nova Scotia anhydrite.

Tariffs

Canada Item No.		British Preferential	Most Favoured Nation	General
29200-1	Gypsum, crude	free	free	free
29300-1	Plaster of paris, or gypsum calcined, and prepared wall plaster, the weight of the package to be included in the weight for duty, per 100 pounds	free	6¢	12½¢
29400-1	Gypsum, ground not calcined	free	free	15%
28410-1	Gypsum tile	15%	15%	25%

United States Item No.		On and After January 1 1971	1972
512.21	Gypsum, crude	free	
512.24	Gypsum, ground calcined	71¢ per long ton	59¢ per long ton
245.70	Gypsum or plaster building boards and lath	7%	6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated 1972) TC Publication 452.

Indium

G.S. BARRY

Indium occurs as a minor constituent of certain ores of zinc, lead, tin, tungsten and iron. It is commonly associated with sphalerite, the most abundant zinc mineral. Indium becomes concentrated in zinc residues and smelter slags derived from zinc and lead smelting operations. It is recovered at only a few of the world's zinc and lead smelters.

Cominco Ltd. is the only Canadian producer of indium and is one of the world's largest producers. Its output in 1972 totalled 462,000 troy ounces; in 1971, output was 394,000 ounces. Production was 898,000 ounces in 1970.

Indium is produced in the United States, Japan, Belgium, Peru, U.S.S.R. and West Germany, as well as in Canada. Statistics on output and consumption are not generally available.

Production

Indium was first recovered at Trail in 1941, though the presence of indium in the lead-zinc-silver ores of Cominco's Sullivan mine at Kimberley, British Columbia, had been known for many years. In the following year, 437 ounces were produced by laboratory methods. After several years of intensive research and development, production began in 1952 on a commercial scale. At present, the potential annual production at Trail is 1 million troy ounces, or about 35 tons.

Indium enters the Trail metallurgical plants with the zinc concentrates. In the electrolytic zinc process, indium remains in the zinc calcine during roasting and in the insoluble residue during leaching. The residue is then delivered to the lead smelter for recovery of contained lead and residual zinc. In the lead blast furnaces, the indium enters lead bullion and blast furnace slag in about equal proportions. From the slag, it is recovered along with zinc and lead during slag-fuming. The fume is leached for recovery of zinc, and indium again remains in the residue, which is retreated in the lead smelter. From the lead bullion, indium is removed in bullion dross. The dross is retreated for recovery of copper matte and lead, and in this process a slag is recovered which contains lead and tin together with 2.5 to 3.0 per cent indium.

The dross retreatment slag is reduced electrothermally to produce a bullion containing lead, tin, indium and antimony, which is treated electrolytically to yield a high (20 to 25 per cent) indium anode slime. The anode slime is then treated chemically to give a crude (99 per cent) indium metal, which is refined electrolytically to produce a standard grade (99.97 per cent) or high-purity grade (approximately 99.999 and 99.9999 per cent) indium. The metal is cast in ingots varying in size from 10 ounces to 10 kilograms. Also produced are various alloys and chemical compounds of indium such as indium antimonide and a variety of fabricated forms such as discs, wire, ribbon, foil, sheet, powder and spherical pellets.

Properties and uses

Indium is a silvery-white, soft metal that resembles tin in its physical and chemical properties. Its chief characteristics are its extreme softness, its low melting point and high boiling point. It is easily scratched with the fingernail and can be made to adhere to other metals by hand-rubbing. It has a melting point of 156°C. Like tin, a rod of indium will emit a high-pitched sound if bent quickly. The metal has an atomic weight of 114.8; its specific gravity at room temperature is 7.31, which is about the same as that for iron.

Indium forms alloys with silver, gold, platinum and many of the base metals, improving their performance in certain special applications. Its first major use, still an important outlet, was in high-speed silver-lead bearings in which the addition of indium increases the strength, wettability and corrosion resistance of the bearing surface. Such bearings are used in aircraft piston engines, diesel engines and several types of automobile engines; the standard grade (99.97 per cent) is satisfactory for this purpose. Indium is used also in low-melting-point alloys containing bismuth, lead, tin and cadmium, for example a bismuth-tin-cadmium-lead-indium alloy containing 19.1 per cent indium used as a heat fuse melts at 47°C. Indium is also used in glass-sealing alloys containing about equal amounts of tin and indium, in certain solder alloys in which resistance to alkaline corrosion is required, and in gold dental alloys.

Indium is one of several metals that finds application in various semiconductor devices. In these, high-purity, indium bonded in the form of discs or spheres onto each side of a germanium wafer, modifies the properties of the germanium. Indium is especially suitable for this purpose because it alloys readily with germanium at low temperatures and, being a soft metal, does not cause strains on contracting after alloying.

Discovered in 1863 but in commercial use only since 1934, indium and its compounds are relatively new materials whose potential applications are still being explored. Uses have been found in electrical contacts, resistors, thermistors and photoconductors. Indium can be used as an indicator in atomic reactors since artificial radioactivity is easily induced in indium by neutrons of low energy. Indium compounds added to lubricants have been found to have a beneficial anticorrosive effect. It is used in certain very small lightweight batteries. Indium has possible applications in decorative plating of jewelry and tableware.

Foreign trade

Statistics on foreign trade are not generally available for indium. United States imports in 1972 totalled 627,800 troy ounces, obtained as follows: 209,928 ounces from Canada, 5,449 from The Netherlands, 18,452 from Japan, 94,104 from Peru, 44,440 from West Germany, 85,185 from Britain and 170,242 from the U.S.S.R. Imports from the U.S.S.R. increased from 29,316 ounces in 1971.

Prices

Prices of indium as quoted in *Metals Week* remained unchanged to November 21/72 from those established September 19, 1968 as follows:

	($ per troy oz)
Sticks, 30-90 troy oz	2.50
Ingot, 100 troy oz	2.05
10,000+ troy oz	1.75

On November 21, 1972 *Metals Week* began quoting only one price: U.S. Ingot $1.75 per troy oz. It is understood that some imports to the United States in 1972 were entering at substantially lower prices. Prices were firmer at the beginning of 1973 and discounting is being discontinued. The outlook for 1973 and 1974 is for a strong demand.

Iron Ore

P. LAFLEUR

Canadian iron ore production and shipments in 1972 were substantially below those in 1971. This was mainly a result of protracted labour strikes at Canada's three largest mines in Quebec-Labrador. Other contributing factors included closure of two byproduct operations, an across-the-board cut in contracted tonnages by Japanese steel producers and a Japanese seamen's strike which affected shipments to Japan.

Since a large proportion of Canadian iron ore shipped in any year is exported, the Canadian iron ore industry is predictably sensitive to world market conditions. This was particularly evident in 1971 when exports were low because of the dampening effect of the world monetary situation together with a slackness of the world steel industry. The consequent buildup in iron ore stocks and inventories of finished steel by the end of 1971, combined with a reduction in Japanese projected iron ore imports were expected to result in reduced exports from Canada in 1972. However, when world steel consumption and production began to accelerate, soon liquidating finished steel and iron ore stocks, the Canadian iron ore industry was unable to increase deliveries because of its inability to produce and ship. Domestic shipments, on the other hand, were up slightly to meet part of the increased requirements of the Canadian steel industry, which had record production in 1972; other supplies came from imports, which were slightly above the previous year's level, and from stocks at steel plants that were in excess of usual year-end amounts at the end of 1971.

With the closure of two byproduct operations during the year, production capacity at the end of 1972 was 47.35 million tons* including 25.03 million tons of pellet capacity. While construction activity continued from the previous year on three large Quebec-Labrador iron ore projects with a combined annual capacity of 32 million tons, the two Iron Ore Company of Canada projects comprising half the tonnage were affected by the strikes forcing the postponement of their opening date from late 1972 to 1973; construction of the Quebec Cartier Mining Company, Mt. Wright project of 16 million tons annual capacity was on schedule and is expected to be completed in late 1974. On the negative side in 1972, Cominco Ltd. and Falconbridge Nickel Mines Limited closed their byproduct operations.

All the major world steel producers increased steel production in 1972 and total output rose by 8 per cent to a record 629 million metric tons. While iron ore consumption paralleled the increased steel production, shipments were lower than in the previous year reflecting the liquidation of iron ore stocks that had accumulated at the end of 1970 and in 1971.

The outlook for the Canadian iron ore industry appears excellent for 1973 and the decade ahead. Domestic shipments should increase to parallel the 5 per cent growth in Canadian steel production next year and during the rest of the 70's; exports should do at least as well and perhaps better. Present capacity and projects currently under construction or expansion throughout the world will be sufficient to supply the annual growth rate in iron ore demand of some 5 per cent until about 1976. Canada should benefit from the additional supplies that will be needed in the late 70's but it will require another round of expansion.

World iron ore requirements for 1980 are estimated at slightly more than a billion metric tons of which domestic supply and imports will be about in balance. Trade will increase substantially indicating a depletion or phasing out of many present domestic supply sources and development of new supply sources in countries that are not now producers. Brazil, Australia, Canada and West Africa appear to have the best potential for new building and expansion.

Production and shipments

Shipments were mainly affected by protracted labour strikes at Canada's three largest mines in Quebec-Labrador. They therefore totalled only 38.7 million tons (39.0 million dry tons in Table 1) compared with 43.3 million tons (42.3 million dry tons in Table 1) the year before and a record of 46.7 million tons in 1970. While exports were down by 4.5 million tons to 29.1 million tons, domestic shipments were up slightly by 200,000 tons to 9.9 million tons. Production, which was affected more than shipments by the labour situation, was only 35.5 million tons compared to 45.7 million tons the year before. The excess of shipments over production, some 3.4 million tons, came from stocks at mines and ports.

Iron ore was produced by 17 companies at 18 locations with 10 operations in Ontario, three in British Columbia, two in Quebec, two in Newfoundland (Labrador) and one in Quebec-Labrador. Two

* The long or gross wet ton (2,240 pounds) is used throughout unless otherwise stated.

Table 1. Canada, iron ore production and trade, 1971-72

	1971		1972p	
	(long tons)[1]	($)	(long tons)[1]	($)
Production (shipments)				
Newfoundland	19,532,997	289,912,158	16,388,000	245,136,000
Ontario	9,980,955	136,205,400	11,430,000	161,281,000
Quebec	11,041,684	110,864,558	10,060,000	99,253,000
British Columbia	1,723,097	18,153,612	1,149,000	11,480,000
Total	42,278,733	555,135,728	39,027,000	517,150,000
Byproduct iron ore[2]	924,000		746,000e	
Imports				
United States	1,272,047	17,589,000	1,472,961	20,161,000
Sweden	–	–	56,235[3]	977,000
Liberia	–	–	159,907[4]	801,000
Brazil	89,618	1,090,000	35,700[3]	352,000
West Germany	29	. . .	28	. . .
Total	1,361,694	18,679,000	1,724,831[5]	22,291,000
Exports				
Iron ore, direct shipping				
United States	4,113,714	40,278,000	3,084,699	29,106,000
Britain	1,280,975	9,128,000	1,074,363	7,604,000
Italy	517,485	3,870,000	911,561	6,236,000
Other countries	43,888	427,000	–	–
Total	5,956,062	53,703,000	5,070,623	42,946,000
Iron ore concentrates				
United States	4,260,295	46,908,000	3,934,646	40,053,000
Japan	2,969,511	25,032,000	1,706,255	15,030,000
Netherlands	1,729,509	13,677,000	1,536,556	11,811,000
Britain	1,659,534	13,397,000	1,293,545	10,170,000
West Germany	1,229,180	9,948,000	763,814	5,952,000
France	154,862	1,265,000	300,187	2,359,000
Belgium and Luxembourg	41,644	305,000	48,531	541,000
Finland	79,848	633,000	27,797	218,000
Australia	–	–	16,170	191,000
Bahamas	14,896	161,000	16,290	169,000
Total	12,139,279	111,326,000	9,643,791	86,494,000
Iron ore, agglomerated				
United States	11,186,071	178,479,000	10,609,600	166,614,000
Britain	1,720,159	27,586,000	1,123,932	17,649,000
Spain	588,109	9,513,000	785,206	12,496,000
Italy	976,098	15,682,000	446,322	7,129,000
Netherlands	256,100	4,107,000	357,670	5,601,000
Japan	130,394	2,107,000	180,790	2,900,000
Belgium and Luxembourg	22,760	364,000	52,060	815,000
France	41,580	667,000	–	–
Total	14,921,271	238,505,000	13,555,580	213,204,000
Iron ore, not elsewhere specified				
United States	536,844	9,123,000	516,822	8,947,000
Netherlands	–	–	20,461	941,000
Britain	53,414	506,000	5,000	148,000
Nigeria	17,410	169,000	–	–
Total	607,668	9,798,000	542,283	10,036,000

Table 1 (cont'd)

	1971		1972p	
	(long tons)[1]	($)	(long tons)[1]	($)
Total exports all classes				
United States	20,096,924	274,789,000	18,145,767	244,720,000
Britain	4,714,082	50,617,000	3,496,840	35,571,000
Netherlands	1,985,609	17,784,000	1,914,687	18,353,000
Japan	3,099,905	27,139,000	1,887,045	17,930,000
Italy	1,493,583	19,552,000	1,357,883	13,365,000
Spain	588,109	9,513,000	785,206	12,496,000
West Germany	1,229,180	9,948,000	763,814	5,952,000
France	196,442	1,932,000	300,187	2,359,000
Belgium and Luxembourg	108,292	1,096,000	100,591	1,356,000
Finland	79,848	633,000	27,797	218,000
Australia	–	–	16,170	191,000
Bahamas	14,896	161,000	16,290	169,000
Nigeria	17,410	168,000	–	–
Total	33,624,280	413,332,000	28,812,277	352,680,000

Source: Statistics Canada.
[1] Dry long tons for production (shipments) by province; wet long tons for imports and exports. [2] Total shipments of byproduct iron ore compiled by Mineral Resources Branch from data supplied by companies. Total iron ore shipments include shipments of byproduct iron ore. [3] Tonnage unloaded at Contrecoeur for local delivery to the Sidbec steel plant. [4] Transshipped to the United States and should not be considered as imports. [5] Imports amount to 1,564,924 tons excluding the Liberian ore transshipped to the United States.
p Preliminary; – Nil; e Estimated; . . . Less than $1,000.

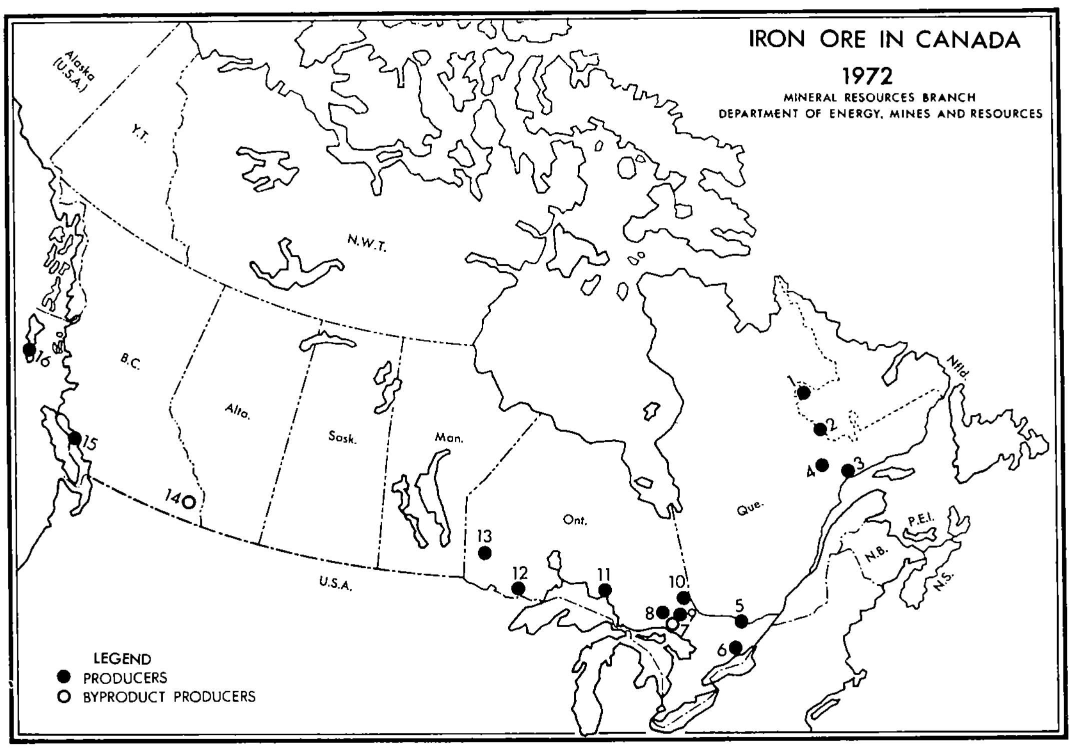
byproduct operations were closed in 1972. They were the Cominco Ltd. iron ore recovery plant and the Falconbridge Nickel Mines Limited pyrrhotite plant. Estimated production capacity at the end of the year was therefore 47.35 million tons, of which 25.03 million tons was pellet capacity.

All the provinces except Ontario had decreased shipments in 1972 (Statistics Canada, Table 1). Newfoundland, the largest producer, recorded the largest decrease with shipments of 16.4 million dry tons, down 3.1 million tons from the previous year, followed by Quebec with shipments of 10.1 million dry tons, down 0.9 million ton and by British Columbia with consignments of 1.1 million dry tons, down 0.6 million ton. Ontario shipments were up fractionally by 0.4 million dry ton to 11.4 million tons.

In Quebec-Labrador, shipments from the three largest Canadian producers were down from 1971 because of a series of labour strikes lasting from 6 to 12 weeks. However, shipments exceeded production by 2.0 million tons because some shipments continued despite the halting of all production; stocks at mines and ports went down accordingly. Shipments by Iron Ore Company of Canada (IOC), the largest Canadian producer, totalled 13.6 million tons compared with 17.2 million tons in 1971 and was comprised of 8.0 million tons of pellets, 5.0 million tons of direct-shipping ore and 578,000 tons of concentrate. Quebec Cartier Mining Company (QCM) and Wabush Mines shipped 7.4 and 5.3 million tons, respectively, compared with 7.9 and 5.6 million tons the year before. The Hilton Mines, a Quebec producer about 40 miles from Ottawa and the only Quebec iron mine not on the Labrador Trough, operated at near-capacity during the year and shipments, all by rail to U.S. and Canadian consumers, at 877,544 tons were slightly above those in 1971.

The construction of three large iron ore projects in Quebec-Labrador continued in 1972 but at two of them – IOC's 10-million-ton-a-year expansion of the Carol Lake concentrator and the two 6-million-ton-a-year pellet plant at Sept-Iles – labour strikes forced rescheduling of start-up operations from late 1972 to early 1973. Total cost of the IOC expansion including common services and interest, will be about $390 million. Construction employment aside, some 1,350 new jobs will be created at IOC's two projects (800 for the Sept-Îles facilities and 550 for the Carol expansion) and an estimated 2,000 at QCM's new Mt. Wright facilities. The 16-million-ton-a-year Mt. Wright concentrator of Quebec Cartier Mining is expected to start production in 1974 with full capacity achieved in 1975. Developments under way by the company in 1972 included the extension of its present rail mainline 88 miles from Gagnon to Mt. Wright, the construction of the new concentrator, establishing a new town called Fermont that is 15 miles east of Mt. Wright, building a new power transmission line, and preproduction stripping of its mine site at Mt. Wright.

With high domestic and U.S. demand, most Ontario mines shipped iron ore at near their production capacities in 1972. In the Atikokan area, the largest Ontario producer, Caland Ore Company Limited, shipped 1.9 million tons compared with 1.5 million tons in 1971 when operations were closed temporarily to match supply with low demand from its U.S. parent and only consumer, Inland Steel Company. Its 1972 open-pit production was below target because of a one-week strike, serious manpower shortages and turnover, and mechanical problems. The company expects to have normal production in 1973 and some 2.0 million tons of shipments are anticipated. Because of the reduced demand for natural ore products, plans have been made by Caland to conclude its mining operation at the end of 1976. It is expected that the pellet plant will continue in production using stockpiled minus 3/8-in partially dried ore



Producers
(numbers refer to numbers on map)

1. Iron Ore Company of Canada (Schefferville)
2. Iron Ore Company of Canada (Labrador City)
   Scully Mine of Wabush Mines (Wabush)
3. Pointe Noire Division of Wabush Mines (Pointe Noire)
4. Quebec Cartier Mining Company (Gagnon)
5. The Hilton Mines (Shawville)
6. Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company (Marmora)
8. National Steel Corporation of Canada, Limited (Capreol)
9. Sherman Mine of Dominion Foundries and Steel, Limited (Temagami)
10. Adams Mine of Dominion Foundries and Steel, Limited (Kirkland Lake)
11. Algoma Ore Division of The Algoma Steel Corporation, Limited (Wawa)
12. Caland Ore Company Limited (Atikokan)
    Steep Rock Iron Mines Limited (Atikokan)
13. The Griffith Mine (Bruce Lake)
15. Texada Mines Ltd. (Texada Is.)
16. Wesfrob Mines Limited (Moresby Is.)

Byproduct producers

7. Falconbridge Nickel Mines Limited (Falconbridge)
   a. Pyrrhotite Plant – closed in 1972
   b. Iron-Nickel Refinery – closed in 1972
   The International Nickel Company of Canada, Limited (Copper Cliff)
14. Cominco Ltd. (Trail) – closed in 1972

Table 2. Canada, iron ore producers, 1971 and 1972

Company and Property Location	Participating Companies	Material Mined and/or Treated	Product Shipped	Shipments 1971	Shipments 1972
		(% Fe natural)	(% Fe dry/wet)	('000 wet long tons)	
Adams Mine; Boston Twp., near Kirkland Lake, Ont.	Dominion Foundries and Steel, Ltd. (acquired from Jones & Laughlin Mining Company, Ltd. July 30, 1971); managed by Cliffs of Canada Limited, a wholly-owned subsidiary of The Cleveland-Cliffs Iron Company	Magnetite from open-pit mine (19)	pellets (66/65)	1,036	1,093
Algoma Ore Division of The Algoma Steel Corp., Ltd.; mines and sinter plant near Wawa, Ont.	Wholly owned	Siderite from open-pit and underground mines (34)	Siderite sinter (48/48)	1,628[2]	1,797[3]
Caland Ore Co. Ltd.; East arm of Steep Rock Lake, near Atikokan, Ont.	Inland Steel Co.	Hematite and goethite from open-pit mine (54)	Pellets (63/63) Concentrate (59/56)	859 612	1,115 783
Griffith Mine, The; Bruce Lake 35 miles south of Red Lake, Ont.	The Steel Co. of Canada, Ltd.; managed by Pickands Mather & Co.	Magnetite from open-pit mine (24)	Pellets (67/67)	1,364	1,380
Hilton Mine, The; near Shawville, Quebec, 40 miles NW of Ottawa	The Steel Co. of Canada, Ltd., 50%; Jones & Laughlin Steel Corp., 25%; Pickands Mather & Co. (managing agent), 25%	Magnetite from open-pit mine (25e)	Pellets(67/67)	869	878
Iron Ore Company of Canada	Labrador Mining and Exploration Co. Ltd., 4.73%;				
1. Schefferville, Que., operation	Hollinger Mines Ltd., 10.17%; The Hanna Mining Co. (managing agent)	Hematite-goethite-limonite from open-pit mines (54)	Direct-shipping ore (59/54)	5,922	5,046

Table 2 (cont'd)

Company and Property Location	Participating Companies	Material Mines and/or Treated	Product Shipped	Shipments 1971	1972
		(% Fe natural)	(% Fe dry/wet)	('000 wet long tons)	
2. Carol Lake, Labrador operation[4]	26.37%, Armco Steel Corp., 5.87%; Bethlehem Steel Corp., 18.80%; Youngstown Sheet and Tube Company[5], 5.87%; National Steel Corp., 17.62%; Republic Steel Corp., 5.87%; Wheeling-Pittsburgh Steel Corp., 4.70%	Specular hematite and some magnetite from open-pit mines	Pellets (65/64) Concentrate (66/63)	9,476 1,795	7,985 578
Marmoraton Mining Co., Division of Bethlehem Chile Iron Mines Company; near Marmora, Ont.	Bethlehem Steel Corp.	Magnetite from open-pit mine (20e)	Pellets (65/65)	474	490
National Steel Corporation of Canada, Ltd., Moose Mountain Mine; Sudbury area, 20 miles north of Capreol, Ont.	National Steel Corp. (The Hanna Mining Co. is the managing agent)	Magnetite from open-pit mine (33)	Pellets (63/63)	681	641
Quebec Cartier Mining Co.; Gagnon, Quebec	Un'ted States Steel Corp.	Specular hematite from open-pit mine (33)	Specular hematite concentrate (66/64)	7,864	7,432
Sherman Mine; near Temagami, Ontario	Dominion Foundries and Steel, Limited, 90%; Tetapaga Mining Company Limited (wholly-owned subsidiary of The Cleveland-Cliffs Iron Company), 10%. The operation and management of the mine is by Cliffs of Canada Limited, also a wholly-owned subsidiary of The Cleveland-Cliffs Iron Company	Magnetite from open-pit mines (24)	Pellets (66/65)	1,026	1,052

Table 2 (cont'd)

Company and Property Location	Participating Companies	Material Mines and/or Treated	Product Shipped	Shipments 1971	1972
		(% Fe natural)	(% Fe dry/wet)	('000 wet long tons)	
Steep Rock Iron Mines Ltd.; Steep Rock Lake, N. of Atikokan, Ont.	Publicly-owned company	Hematite-goethite from open-pit mine (55e)	Concentrate (58/54)	5	7
			Pellets (63/63)	1,411	1,467
Texada Mines Ltd.; Texada Island, B.C.	Kaiser Aluminum & Chemical Corp.	Magnetite and chalcopyrite from underground mines (35)	Magnetite concentrate (65/61)	512	614
Wabush Mines, Scully Mine includes mine and concentrator at Wabush, Labrador; Pointe Noire Division includes pelletizing plant at Pointe Noire, Que.	The Steel Co. of Canada, Ltd., 25.6%; Dominion Foundries and Steel, Ltd., 16.4%; Youngstown Sheet and Tube Company[5], 15.6%; Inland Steel Co., 10.2%; Interlake, Inc., 10.2%; Wheeling-Pittsburgh Steel Corp. 10.2%; Finsider of Italy, 6.6%; and Pickands Mather & Co. (managing agent), 5.2%	Specular hematite and some magnetite from open-pit mine (33)	Pellets (66/64)	5,597	5,310
			Concentrate (66/64)	–	3
Wesfrob Mines Limited; Tasu Harbour, Moresby Is., Queen Charlotte Is., B.C.	Falconbridge Nickel Mines Limited	Magnetite and chalcopyrite from open-pit mines (37)	Pellet-feed concentrate (69/63)	727	330
			Sinter-feed concentrate (61/58)	528	284
Byproduct Producers					
Cominco Ltd.[6]; Kimberly, B.C.	Publicly-owned company	Pyrrhotite flotation concentrates roasted for acid production; calcine sintered	Iron oxide sinter (63/63) is processed into pig iron at plant	47[7]	28[7]

Table 2 (concl'd)

Company and Property Location	Participating Companies	Material Mined and/or Treated	Product Shipped	Shipments 1971	1972
		(% Fe natural)	(%Fe dry/wet)	('000 wet long tons)	
Falconbridge Nickel Mines Ltd.[6], Falconbridge, Ont.	Publicly-owned company	Pyrrhotite flotation concentrates (57) treated	Calcine (67/67)	82	19
The International Nickel Co. of Canada, Ltd.; Copper Cliff, Ont.	Publicly-owned company	Pyrrhotite flotation concentrates (57) treated	Pellets (68/68)	796	700
Quebec Iron and Titanium Corp.; mine at Lac Tio, Que.; electric smelter at Sorel, Quebec	Kennecott Copper Corp.; Gulf & Western Industries Inc. (The New Jersey Zinc Co.)	Ilmenite-hematite ore (40% Fe, 35% TiO_2) from open-pit mine at Lac Tio, beneficiated and calcined at Sorel	Ilmenite calcine electric smelted to TiO_2 slag and various grades of desulphurized pig iron or remelt iron	1,863[8]	2,017[8]

Sources: Company reports, personal communicat.ons and others.
[1]Exclusive of Craigmont Mines Limited which ships magnetite byproduct concentrate to western Canada coal preparation plants; [2]comprising 1,539,648 tons of superfluxed sinter, 86,393 tons of regular sinter, and 2,237 tons of crude ore shipped to the U.S.A. to be used as a food supplement in the livestock industry; [3]Comprising 1,652,766 tons of superfluxed sinter, 142,566 tons of regular sinter, and 1,448 tons of crude ore (for special use); [4]The assets of the Carol Pellet Company, which was established to pelletize concentrates produced by IOC, were acquired by IOC on December 31, 1970; [5]Operating subsidiary of Lykes-Youngstown Corporation; [6]Closed in 1972; [7]Sinter consumed in pig iron production; [8]Ilmenite calcine smelted.
[e]Estimated; – Nil.

until January 1978. At the conclusion of ore mining operations, the lease to the Caland property will be surrendered to Steep Rock Iron Mines Limited, which may continue mining operations to supply ore to its own plant.

The other producer in the Atikokan area, Steep Rock Iron Mines Limited, operated at capacity and 1.5 million tons of iron ore were shipped, including 245,000 tons to the United States. Ore production came from the South Roberts and Hogarth open-pit mines and the Errington underground mine. However, the South Roberts mine was closed during the year after the economic limit of open-pit mining was reached. With raw feed from its other two mines, the pellet plant is expected to operate at capacity in 1973.

Operations were normal at other Ontario mines. The Griffith Mine operated at capacity and shipped some 1.4 million tons of pellets to its parent, The Steel Company of Canada, Limited at Hamilton, Ontario. During 1973, the company will open the south pit and begin a two-year dredging and dyking operation to further extend the existing north pit. The expansion of pit work and other mining activities will not raise the current annual capacity of 1.5 million tons a year, but it will add some 100 permanent jobs to the present 400-man payroll. Production at the Algoma Ore Division of The Algoma Steel Corporation, Limited was at capacity and it shipped some 1.8 million tons of sinter, mostly superfluxed, to the steel company's blast furnaces at Sault Ste. Marie and Port Colborne, both in Ontario. Installation of equipment for cooling, crushing and cold screening, was completed in 1972 making the production of more uniform-sized sinter possible. Production was normal at the Sherman Mine, the National Steel Corporation of Canada, Limited, and Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company pellet plants and shipments were 1.1 million tons, 641,000 tons and 490,000 tons, respectively. The Adams Mine completed its first full year of operation under the management of Cliffs of Canada Limited for the new owners, Dominion Foundries and Steel, Limited (Dofasco). Of the total shipments of about 1.1 million tons, 713,000 million tons went to Dominion Foundries with the remainder being exported to its former owner in the United States. Dofasco will be taking increasing shipments as the need arises.

The iron ore position and outlook in the Sudbury basin became less promising in 1972. Although The International Nickel Company of Canada, Limited produced and shipped about 700,000 tons of iron ore pellets in 1972, operations were well below capacity. The company announced in 1971 that it would be producing at a reduced rate in order to meet the new Ontario regulations on sulphur dioxide emissions. It also decided to cancel the nearly completed 250,000-ton-a-year pellet plant expansion because of new anti-pollution requirements, increased construction costs and marketing factors. In 1972, Falconbridge Nickel Mines Limited closed its pyrrhotite plant to reduce pollution and, as a result, shipped only 19,000 tons of calcine. Furthermore, Falconbridge closed its new Iron-Nickel Refinery in early 1973 after only two years of operation because of technical difficulties in processing. Designed to produce 300,000 tons of reduced pellets containing 92 per cent iron and 1.5 per cent nickel, the plant fell well short of the goal and in 1972 shipped only about 29,000 tons.

British Columbia producers also experienced difficulties during the year. Wesfrob Mines Limited, with only limited storage capacity, was forced to halt production temporarily at its mine because of a Japanese seamen's strike that halted all deliveries to Japan. Previously, the Japanese have opted for minimum tonnages of both pellet and sinter feeds, and Midland-Ross Corp. a United States producer of reduced iron, also reduced its need of concentrate for pelletizing. Shipments, therefore, were limited to 614,000 tons, down considerably from the 1.3 million tons shipped in 1971. Texada Mines Ltd., unaffected by the seamen's strike because it ships to Japan with its own bulk carrier, exported some 0.5 million ton, about the same as in 1971. Cominco Ltd. closed its iron ore recovery plant in 1972 after the breakdown of the largest of its two pig iron furnaces the previous year made the operation no longer economic. Sinter consumption in the production of pig iron amounted to 28,000 tons during the year.

Trade

Exports during the year totalled 28.8 million tons (Table 1) compared with 33.6 million tons in 1971 and a record 38.7 million tons in 1970. Exports were affected mainly by the Quebec-Labrador labour strikes, and by the across-the-board cut in contracted

Table 3. Production and capacity of pig iron and crude steel at Canadian iron and steel plants, 1971-72

	1971	1972^p
	(short tons)	
Pig iron		
Production	8,615,756	9,363,893
Capacity at December 31	10,907,000	11,115,000
Steel ingots and capacity		
Production	12,169,552	13,072,873
Capacity at December 31	15,031,600	15,537,800

Source: Statistics Canada, Primary Iron and Steel.
^{p}Preliminary.

tonnages with Canadian producers as part of the program by Japan to balance its imports with requirements, and a Japanese seamen's strike. Another contributing factor was the sale by a United States iron and steel producer of the Adams Mine to a Canadian steel company, which diverted 0.7 million ton of potential exports to the domestic market.

The largest market, the United States, took 18.1 million tons (compared with 20.1 million tons in 1971) followed by the ECSC with 5.3 million tons (5.0 million tons), and Britain with 3.5 million tons (4.7 million tons). Of the imports by the ECSC, the Netherlands led with 1.9 million tons (about half is transshipped to West Germany), followed by Italy with 1.4 million tons, West Germany with 0.8 million ton, France with 300,000 tons, and Belgium-Luxembourg with 101,000 tons. Shipments to West Germany were considerably down from the previous year while those to Italy, Netherlands, Belgium and Luxembourg were either lower or about the same; French shipments, which began in 1969, were up slightly. Spain, with shipments of 0.8 million ton, continued to offer a growing market for Canadian iron ore. Finnish shipments, which began in 1968, and were at the 80-90,000-ton level between 1969 and 1971, amounted to only 28,000 tons in 1972.

Imports at 1.6 million tons (Table 1: 1.7 million tons less 159,907 tons of Liberian ore transshipped through the port of Contrecoeur to the United States), were up slightly from 1971 and represents only the second reversal in their downward trend since 1964. However, imports are expected to increase by 1.7 million tons to about 3.0 million tons after 1974 when the Tilden Mine in the United States is expected to go into production. The Cleveland-Cliffs Iron Company's mine in Michigan is currently in the development stage and according to agreements signed in 1971, Algoma and Stelco will take 1.2 and 0.5 million tons a year, respectively. Imports of Swedish and Brazilian ore went to the new Sidbec reduction plant at Contrecoeur, Quebec. For the first time in many years, Sydney Steel Corporation's requirements were met entirely from Canadian ores.

Table 4. Receipts, consumption and stocks of iron ore at Canadian iron and steel plants, 1971-72

	1971	1972
	(long tons)	
Receipts imported	1,338,703	1,523,839[1]
Receipts from domestic sources	9,937,193	9,741,839[2]
Total receipts at iron and steel plants	11,275,896	11,265,678
Consumption of iron ore	10,837,974	11,711,134[3]
Stocks of ore at iron and steel plants, December 31	4,527,314	4,031,719[4]
Change from previous year	+386,685	-495,595[5]

Source: American Iron Ore Association, compiled from company submissions.
[1]Compared with 1,564,924 tons in Table 1. Table 1 includes receipts from Brazil and Sweden by the Sidbec steel reduction plant, which did not report statistics to American Iron Ore Association in 1972 (the reduction plant began operation in early 1973). [2]Compared with domestic shipments of 9,864,234 tons compiled by Mineral Resources Branch. Shipments from mine and receipts at steel plant do not coincide because of stockage at lake port site. [3]Compared with 11,668,945 tons compiled by Mineral Resources Branch. [4]Including 56,235 tons from Sweden and 35,700 tons from Brazil (Table 1) that were not consumed by Sidbec in 1972, total stocks amount to 4,123,654 tons. [5]Because of stocks at Sidbec the change from the previous year amounts to an estimated 403,666 tons (-495,595 + 56,235 + 35,700).

Consumption

Domestic shipments at 9.9 million tons were higher than in 1971 and established a new record. The loss in domestic shipments by the closure of the two byproduct plants and a labour strike at Wabush Mines, 42 per cent Canadian-owned, was more than balanced by higher domestic deliveries from Ontario producers, especially from the Adams Mine. However, receipts at steel plants as reported by the American Iron Ore Association (Table 4) were slightly less at 9.7 million tons (shipments from mine and receipts at steel plant rarely coincide exactly because of stockage at lake port site). Consumption of iron ore at 11.7 million tons (Table 4) exceeded combined imports of 1.6 million tons and receipts of 9.7 million tons by 0.4 million ton and stocks at iron and steel plant sites went down accordingly. Excluding new iron ore screenings that were sintered, pellets comprised 81 per cent of total consumption, the same as the year before.

World supply and demand

All the major steel producers had increased steel production in 1972 when total output rose by 8 per cent to a record 629 million metric tons (*Metal Bulletin*, June 1, 1972). The record comes after a decline in 1971 when total output fell from 1970 output by about 2 per cent to 583 million metric tons. However, the rate of the increase was below that recorded in 1969 when it rose about 8.6 per cent from the output of the previous year. The United States had the largest absolute rise with 12 million metric tons, followed by Japan with 8 million metric tons, and the U.S.S.R. with 5.4 million metric tons; the other large steel-producing area, the ECSC, increased its production by 9.8 million to 113.2 million metric tons. For the year, the U.S.S.R. ranked first, a position it gained from the United States in 1971, with 130 million metric tons, followed by the United States with 124 million tons, and Japan with 97 million tons. Canada with only 2 per cent of world production of steel was ranked 12th among world steel producers. Among the developing countries, Brazil and Mexico stood out as the steel producers with largest increases in terms of output.

World iron ore shipments at an estimated 759 million metric tons were down 11 million tons from 1971 notwithstanding the increase in steel production of 8 per cent. Iron ore consumption was 793 million metric tons (calculated by applying an ore-consumption-to-steel-production ratio of 1.26) compared with 735 million tons the year before. The carryover of some 35 million metric tons of excess stocks from 1971 was responsible for this situation and also accounted for the lower trade volume which was down by about 6 million tons to 315 million tons. However, the trend toward a greater trade volume will continue to reflect both the increasing and continued reliance of some of the major steel producing areas on iron ore imports.

The oversupply situation had its beginning in late 1969 when at the time of traditional renegotiation of iron ore contracts in western Europe, Swedish iron mines were closed by a labour strike. This aggravated an already tightened supply situation brought on by peak European steel production and decreased supplies from Canada. The strike helped to strengthen the bargaining position of most world suppliers to Europe who obtained price increases ranging from 10 to 15 per cent for 1970 delivery. Contracts that were signed for terms of two years and more to assure supply at prices no greater than were newly agreed upon, resulted in overcommitment toward the end of 1970 and especially in 1971.

The situation in Japan developed about mid-1970 when crude steel production began to decline as a reflection of a similar and more pronounced decline in domestic steel demand. The policy of obtaining future supplies by means of long-term contracts works to Japan's advantage in expansionary times since it assures adequate supply and low guaranteed prices and it certainly works to the advantage of suppliers who have a guaranteed market and can raise capital for expansion based on these contracts. Not only did Japan fail to achieve its anticipated high growth rate in 1971 but its production level was down some 5 million metric tons from the previous year.

The U.S.S.R. with 208 million metric tons was the leading iron ore producer followed by the United States, Australia, France, China, Brazil and Canada (Table 5). Australia again led major exporters in 1971 with 53 million metric tons while the U.S.S.R. maintained its second position with 38 million tons. Brazil with 31 million metric tons gained third position from Canada with 30 million tons.

Markets and prices – general

Excluding eastern Europe, which imports ores mainly from the U.S.S.R., there are three major trading markets for iron ores – United States, western Europe and Japan. Canada sells in all three with the United States being the most important.

Reversing their upward trend of the previous two years, international fob prices tended to level off in 1972 and in some instances declined. Several factors contributed to this change. They were: fixed prices for long-term contracts; an excess of stocks carried over from 1971; and the fact that some prices negotiated in 1970 for 1971 were also applicable to 1972 deliveries.

International iron ore delivered costs (cif) were another matter because they include not only the fob price but many other variables. Low world shipping rates throughout most of 1972 reduced the average delivered cost of iron ores to Japan and Europe; a rise in lake freight rates after the Lake Erie base prices* were set increased the delivered cost to the buyer in the Great Lakes market. The European and Japanese average import cost was reduced even further in 1972 by the realignment of currencies at the end of 1971 calling for the upward evaluation of European currencies vis-à-vis the U.S. dollar. This is because international iron ore prices as well as most shipping rates are traditionally quoted in U.S. dollars. Theoretically, for ores and charters contracted before the realignment, the reduction in cost amounted to as much as 14 per cent for Japanese imports and from 5 to 12 per cent for European imports.

United States market

Prices for United States domestic shipments and the bulk of its imports are established at the beginning of each year according to a schedule called the Lake Erie base price. This price is applicable to all Canadian and Venezuelan imports as well as to Canadian ores sold to Canadian steel producers.

The Lake Erie base prices stabilized in 1972 at 1971 levels after two consecutive annual increases. Based on the prices listed in Table 6, Iron Ore Company of Canada direct-shipping ore and Quebec Cartier Mining Company concentrate were purchased for about U.S. $11.79 and $13.70 a ton, respectively; at U.S. $0.28 per iron unit, Canadian pellets obtained about $18.20 a ton.

After Canada, Venezuela is the second largest exporter of iron ore to the United States. The price of its direct-shipping ore (58-per-cent-iron base), fob Puerto Ordaz, is tied to the Lake Erie base price for Mesabi non-Bessemer ore. It was from U.S. $8.89

* Closely synonymous with delivered prices since they include fob shipping port and transportation costs, and cost for discharging from hold to rail of vessel. . . . This system is used to determine the 'delivered cost' of ores to all Great Lakes ports.

Table 5. World production* of iron ore, 1971-72

	1971	1972^p
	(000 metric tons)	
Canada	44,007	39,321
United States	78,121	77,746
France	55,858	55,120
Sweden	33,338	33,124
Eastern Europe	14,870	14,950
U.S.S.R.	203,004	208,000
Australia	62,267	62,500
India	33,283	34,150
Brazil	40,523	40,781
Chile	11,265	11,004
Peru	9,350	9,244
Venezuela	19,861^e	17,230
Angola	5,498	5,025
Liberia	21,525	22,750
Mauritania	8,601	8,618
South Africa	10,500	10,100
Others	118,496	108,937
Total	770,367	758,600

Sources: 1971: Mineral Resources Branch
1972: Various statistics including *Metal Bulletin*, April 19, 1973.
*Shipments; ^{e}Estimated; ^{p} Preliminary.

(applicable from February 5, 1972) to $8.96 (November 23, 1972) in 1972 compared with a range of U.S. $8.63 (December 1, 1970) to $8.83 (May 1, 1971) the year before.

The Hanna Mining Company, a large American producer and part owner and operations manager of Iron Ore Company of Canada, was the first to announce price increases for 1973, amounting to 4.7 per cent for natural iron ore and 3.8 per cent for iron ore pellets. Since the price rises essentially reflect increased costs of labour, supplies and transportation, these price increases were adopted by other producers who operate under the same inflationary conditions. A large component of the increased cost to steel producers is for lake transportation which rose in the early part of 1972 some 5.3 per cent, equivalent to an increase of 12 cents a ton, to $2.37 a ton in the basic shipping rate from the head of Lake Superior to the lower lakes. The Hanna Mining Company departed from traditional procedure when it announced another price increase before the start of the 1973 shipping season to cover further increases in rail and vessel rates.

The price increases apply only to merchant ore but the higher transportation and production costs, which are said to be partly responsible for the upward trend, are also applicable to 'captive' ores, the bulk of the ores moved in this market. Thus, steel mills face higher iron ore costs regardless of ore source.

European market

Europe's steel producers, unlike those in the United States and Japan, have relatively unprotected forward positions because about half their ore is obtained by annual contracts, usually negotiated in December. However, the booming steel industry in 1970 caused shortfalls in supply that resulted in spot purchases at high prices. Anticipating high production rates in 1971-72, the Europeans departed from their usual practice and signed contracts for periods of more than one year and many 1971 prices were applicable through 1972.

The prices for Swedish ores, which are normally negotiated annually with the principal western European users and are indicative of the overall supply-demand situation, had been set in 1971 for two years, so that no change occurred. For 1971-72, the price for Kiruna D ore (60 per cent Fe, 1.8 per cent P) was 53.5 Swedish krona per metric ton, cif Rotterdam (U.S.

Table 6. Lake Erie base prices of selected ores, 1964-73

	1964-69	1970	1971-72	1973	1973[1]
			($ U.S. per long ton[2])		
Mesabi Non-Bessemer	10.55	10.80	11.17	11.71	11.91
Mesabi Bessemer (+ phos. premium)	10.70	10.95	11.32	11.86	12.06
Old Range Non-Bessemer	10.80	11.05	11.42	11.96	12.16
Old Range Bessemer	10.95	11.20	11.57	12.11	12.31
High Phosphorous	10.55	10.80	10.80	–	–
Pellets (per ton nat. unit[3])	0.252[4]	0.266	0.280	0.291	0.294

[1]The Hanna Mining Company, operator of Iron Ore Company of Canada, announced price increases in March, 1973 to cover increases in rail and vessel rates. [2]51.5% of iron natural, at rail of vessel, lower lake port; coarse ore premium: 80¢ a ton and penalty for fines: 45¢ a ton. [3]Equals 1% of a ton (i.e., 22.4 lb/lt unit). An iron ore containing 60% Fe, therefore, has 60 units. [4]Price applicable for years from 1962 to 1969.
– Not available

$10.35 at the January 1971 exchange rate; U.S. $11.12 at the January 1972 exchange rate). The cif prices Rotterdam for other ores varied from 14¢ to 17¢ a metric ton iron unit for sinter feed, washed fines or concentrate, about 19¢ for run-of-mine, washed lumpy and rubble ores and 25¢ to 29¢ for pellets.

Spain is a growing market for iron ores, and like Canada and the United States, publishes average fob prices of its imported ores (Table 7).

Prices of Canadian ores destined for the European market averaged about 11.9 cents an iron unit for concentrate compared with an average of about 12.2 cents an iron unit in 1971, and about 24 cents an iron unit for pellets compared to 24.6 cents an iron unit the year before. The downturn in prices reflects a buyers market in Europe during the year, but with the excess stocks having been depleted in 1972 and with another good year predicted for steel production in Europe, prices are expected to improve, especially for concentrates. There are no long-term contracts for pellets, and the market shifts from one consumer to another depending on their immediate needs.

Notwithstanding a rise expected in European imports to match the increase in steel production of 5 per cent or more, increasing tonnages at low prices from Australia because of large reductions in Japanese purchases should stabilize some 1973 prices at the 1971-72 levels. Swedish prices for phosphoric ores were down by as much as 12 per cent from 1972 to reflect mainly the upward revaluation of the German mark relative to the Swedish krona, and the threat of accelerating the phasing-out of high-pollution-prone and high-cost Thomas converters that use phosphorous ores exclusively. However, prices of some other world ores increased, especially for those ores with good sintering characteristics and low sulphur. If iron ore demand increases significantly by mid-1973 spot prices should go up but the upward revaluation of European and Japanese currencies vis-à-vis the U.S. dollar will lower the average import cost into these areas.

Japanese market

The Japanese market was quiet in 1972 and was characterized by about five long-term contract renewals and no spot buying. In fact, to reduce its imports of already-contracted ore to match its requirements, the Japanese exercised options to decrease its intake from 10 to 15 per cent and sought further cutbacks of imports through deferment of shipments.

Australia is the price leader in this market because of the favourable market factors for both the seller and buyer. Because of the favourable high grade, quality and low shipping cost, the Japanese take large volumes from Australia, 43 per cent of total imports in 1972. The prices obtained guarantee a good return on investment for the Australian producer. This mutual satisfaction had kept ore prices low, especially for pellets, and prices of other world ore in this market have had to adjust accordingly. Using average fob value in Table 8 and applying a shipping cost to Japan of $2.40 a ton, the delivered cost to Japan for pellets, lump and sinter feed ore estimated at U.S. $14.24, $11.98 and $10.08 a ton, equivalent, respectively, to about 22.3¢, 18.7¢ and 15.7¢ a long ton iron unit. The cif prices per unit Japan are comparable to those obtained in the European market for similar ores except for pellets, the price of which is anywhere from 2½ cents a unit to 5 cents a unit lower.

Canadian iron ores, except for pellets, compete favourably in the Japanese market. Two contracts of Iron Ore Company of Canada call for a price of U.S. 16.4¢ per dry long ton unit on a special c & f basis with freight rates U.S. $3.775 for one contract (using 165,000-ton vessels) and U.S. $3.155 for the other (using 250,000-ton vessels). A Quebec Cartier Mining contract for 6 million tons (1.2 million tons for five years) calls for a price of U.S. 16.4 cents per dry long ton unit. Texada Mines Ltd. received U.S. $11.62 c & f a dry metric ton for its concentrate and Wesfrob Mines Limited U.S. $9.12 fob a dry metric ton for its sinter feed and U.S. $9.07 fob a dry metric ton for its pellet feed. While the delivered price for Quebec-Labrador concentrates competes favourably with Australian fines at 15.7 cents a unit, British Columbia concentrate prices appear to be high at an estimated

Table 7. Fob prices of Spanish iron ore imports, 1972

	Tons	Price Range[1]
		($ U.S. per long ton)
Mauritania	24,000	10.24 to 10.53 (10.19 to 10.33)
Liberia	250,000	9.56 (10.26)
Brazil	225,000 (pellets)	13.25 (13.58)
	198,000	8.54 to 9.61 (8.28 to 9.90)
Canada	300,000 (pellets)	14.99 (14.66 to 17.43)
Australia	170,000	8.41
South Africa	30,000	8.78
India	47,500	6.14 to 8.22 (6.30)
Sweden	10,000 (pellets)	15.10

Source: *Metal Bulletin.*
[1] 1971 prices in brackets. Original 1972 data in pesetas converted to U.S. dollars using conversion factor of 66:1.

Table 8. Representative fob prices of Australian lump, fines and pellets[1] according to Japanese contracts, 1966-73

	Hamersley Lump	Hamersley Fines	Goldsworthy Lump	Goldsworthy Fines	Mt. Newman Lump	Mt. Newman Fines
	($ U.S./dry long ton, 64% Fe basis)					
1966-67	9.92	7.68	9.86	7.25	Nil	Nil
1968	9.37	7.68	9.37	7.68	9.37	7.13[3]
1969	9.37	7.63	9.37	7.68	–	–
1970	9.58	7.23[3]	9.86	7.95	9.58	7.23[3]
1971	9.58	7.95	9.58	7.25[3]	9.58	7.25[3]
1972[2]	–	–	–	–	–	–
1973	Price increases in mid-1973 averaged 17% for lumps and pellets and 13% for fines.					

Sources: *Japan Commerce Daily* and others.
[1]Long-term pellet contracts in force at year-end 1972 were with Hamersley and Robe River (18.5 U.S. ¢/lt unit); BHP Whyalla (18.3 U.S. ¢/lt unit); and Savage River (50% at 18.5 U.S. ¢/lt unit and 50% at 22 U.S. ¢/lt unit). [2]No spot or pertinent long-term contracts were concluded in 1972. In fact, Japanese steelmakers reduced 1972 intakes substantially from the basic contract volumes. [3]62% Fe.
– No record.

18.7¢ a unit. However, British Columbia sinter and pellet feed should warrant a premium because the ore is comprised of magnetite which, when sintered or pelletized, supplies heat values as well as imparts favourable operating characteristics to the processes.

Currency realignments will have a tremendous impact on prices of world ores entering the Japanese market, especially on prices for Australian ores. In December 1972, Australia raised the exchange value of its currency by 7.4 per cent, independently of other nations, and on February 16, 1973, it again revalued its currency by 11.4 per cent, in response to the devaluation of the U.S. dollar. Therefore, in a matter of only one year and a half, the exchange value of the Australian currency was raised by more than 26 per cent in terms of U.S. dollars. The importance of this currency realignment lies in the fact that all long-term contracts between Australian producers and Japanese consumers are in terms of U.S. dollars. However, the decrease in value of sales did not amount to 26 per cent because costs for labour and supplies are paid in terms of Australian dollars, and most of the capital amortization is in terms of U.S. dollars. The Australian producers were successful, however, in obtaining price increases amounting to about 17 per cent for lump and pellets and 13 per cent for fines, equivalent to an average increase of about 15 per cent or about U.S. $1.80 per ton over the currently contracted prices.

The Brazilians were also able to negotiate in 1973 price increases for their currently-held contracts with Japan. Prices were reported to have been raised from 11 to 17 per cent for an average of 13.5 per cent and will mean in actual dollar value an increase in revenue of about $14 million for the current fiscal year on currently-held contracts. Krivoi Rog ore from the U.S.S.R. and El Romeral ore of Chile were also reported to have obtained price increases. In mid-1973, Japanese steelmakers granted a price increase of 1 U.S. cent per iron to Marcona pellets bringing this key price to U.S. 26.25 cents per metric iron unit cif Japan. Chowgule & Co. Pvt. Ltd. of Goa was also able to negotiate a price increase for its pellets of U.S. 2.1 cents an iron unit bringing the fob price to U.S. 19 cents an iron unit.

Forecast and outlook

The outlook for the Canadian iron ore industry in 1973 appears excellent for both domestic shipments and exports. Domestic consumption of iron ore should parallel the record steel production expected next year and with the principal problems of 1972 in the industry resolved domestic supplies should increase substantially. The highly export-oriented industry should benefit from the 5 per cent increase in world steel production anticipated in 1973, particularly since much of the 16 million tons in new capacity already committed to contract will be available for export. Therefore, shipments in 1973 are forecast at about 53 million tons comprising 11.2 million tons of domestic deliveries and 41.8 million tons of exports (Table 9). The large increase in exports depends very much on when the new plants are brought on stream and on the solving of technical difficulties should they be encountered.

The growth of the Canadian iron ore industry is primarily dependent upon the growth in exports because about 80 per cent of production is currently exported and domestic demand will increase, in terms of tonnages, only moderately. Therefore, to properly assess the role that Canadian iron ores will play in world markets of the future, one must assess the iron ore demand-supply pattern of the world's major steel-producing countries and the role that both domestic and imported ores will have in them.

A recent study* places world steel consumption in 1980 at 935 million metric tons, up 49 per cent from 1972, equal to an annual increase of about 5 per cent compounded (from 1970, a more typical year for production, it was 4.5 per cent, which is more realistic in view of past trends). With the pig iron/raw steel ratio probably remaining at the 1972 level of 0.71, pig iron production is estimated at 670 million metric tons which is equivalent to a total iron content in iron ores of about 603 million metric tons. This translates into iron ore requirements in 1980 of slightly more than a billion metric tons.

* International Iron and Steel Institute; Projection 85, World Steel Demand; March 1972.

Table 9. Canada, raw steel output and iron ore supply-demand, 1970-72, Forecast to 1980

	Raw Steel Production (net tons)	Iron Ore Consumption[1]	Imports	Domestic Shipments	Exports	Total Shipments
			(long tons)			
1970	12.3	11.5	2.1	9.2	38.6	47.8
1971	12.2	10.8	1.4	9.7	33.6	43.3
1972	13.1	11.7	1.6	9.9	29.1	38.9
			Forecast Period			
1973	14.0	12.5	1.3	11.2	41.8	53.0
1974	13.9	12.4	2.0	10.4	49.6	60.0
1975	14.5	13.0	3.0	10.0	55.0	65.0
1976	15.4	13.8	3.0	10.8	57.2	68.0
1977	16.3	14.6	3.0	11.6	53.4	65.0
1978	17.2	15.4	3.0	12.4	55.6	68.0
1979	18.1	16.2	3.0	13.2	57.8	71.0
1980	19.0	17.0	3.0	14.0	66.0	80.0

Source: Mineral Resources Branch.
[1] For the period 1970 to 1972 consumption does not necessarily equal domestic shipments plus imports because of the rise or fall in stocks at steel plants. Variations from year to year in the hot metal/scrap iron ratio affects the relationship between steel production and iron ore consumption.
[p] Preliminary.

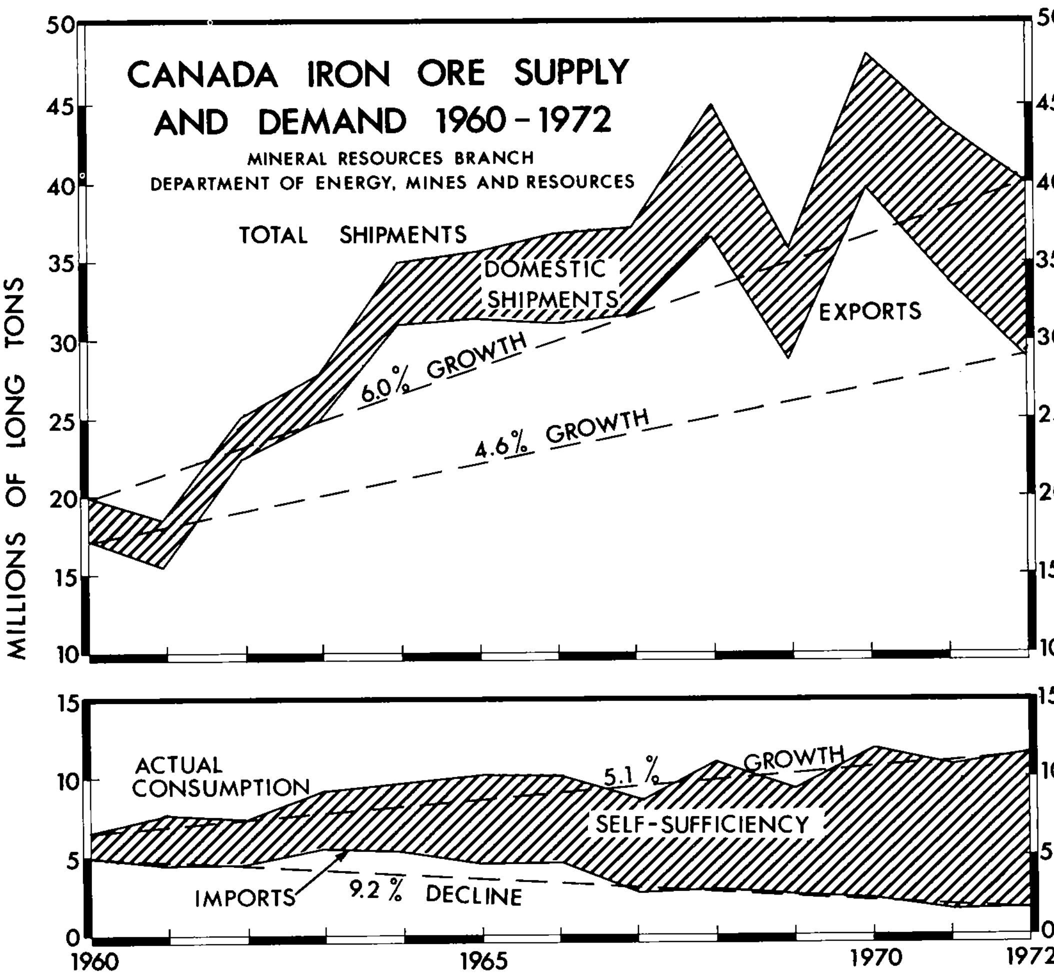
Iron ore trade, which comprised 41 per cent of total shipments in 1972, is expected to be in balance with domestic supply by 1980. This indicates a depletion or phasing-out of domestic sources in many countries concurrent with increased expansion of iron ore imports from established sources and the development of new sources in countries that are not now suppliers. Of total estimated trade of 512 million metric tons in 1980, Japan is expected to take about 205 million tons, the EEC about 165 million tons and the United States about 54 million tons.

Taking into consideration new developments that will come on stream within the next few years, oversupply, resulting from overcapacity, is expected to continue until 1975-76. Additional capacity will be needed from 1976 onwards to match steel growth and, according to several world authorities, will progressively increase to a total of about 175 million tons a year by 1980, or about 35 million tons a year will be needed each year beginning in 1976. A large proportion of the new capacity will find its way to trade, especially in exports to Europe and Japan; about 30 per cent of the new capacity will likely be installed in the U.S.S.R.

What does this mean in terms of new investment? A ton of annual capacity costs about $400 for steel and $30 for iron ore and this applied to an increase in capacity by 1980, means new investment of about $100 billion for steel and some $7.5 billion for iron ore. Furthermore, for transportation of iron ore and coal, an extra 50 million dwt tons of shipping capacity will be needed and at $125 a dwt ton this is equivalent to about $6 billion. Infrastructure and social costs associated with iron ore capacity expansion will at least equal those required for the actual iron ore production facilities. Costs to improve the chemical and physical characteristics of currently-produced ores and improvements in transportation to increase both efficiency and throughput are also considered enormous.

To supply a portion of this growing market, iron ore shipments from Canada in 1975 are expected to reach 65 million tons, comprised of 55 million tons of exports and 10 million tons of domestic shipments (Table 9). By 1980, shipments of 80 million tons comprised of 66 million tons of exports and 14 million tons of domestic shipments are anticipated. The estimate for exports in 1980 may appear high but the 65 million tons as a share of the total potential market of 512 million metric tons, or 13 per cent, was about the same as in 1970 when exports from Canada reached their peak (1972 was a poor reference year because of loss of shipments due to labour strikes).

Notwithstanding the large iron ore resources that exist in many countries, iron ore mining will continue its characteristic trend toward concentration of pro-



duction in large operations in countries whose environments particularly those related to favourable and stable political and fiscal areas, are such that those countries readily lend themselves to investor confidence. Canada has large reserves of iron ore, has achieved and maintained the confidence of investors, has the trained professional, technical and skilled manpower for resource development, and has an advanced and growing industrial support base. Therefore, the Canadian iron ore industry has a large potential for growth in the decade ahead.

Iron and Steel

V.B. SCHNEIDER

Crude* steel production in Canada amounted to 13.07 million tons** in 1972, including 181,067 tons of steel castings, which is a record that resulted from increased production by most steel companies. The major exception was Sydney Steel Corporation (Sysco) where production was lower than in 1971 because of a four week labour strike and because the company's modernization program caused down-time for some of the company's iron and steel making equipment.

The tonnage and value of steel imports again exceeded exports. The value of imports of steel castings, ingots, and rolled products amounted to $458 million, compared with $423 million in 1971. Import tonnages were down in 1972 from 1971 so the increased value reflected higher steel prices. Exports in 1972 amounted to $304 million compared with $312 million in 1971, reflecting a slight decrease in export tonnage. Most Canadian steel facilities operated at or near capacity during the year so imports supplemented domestic supplies rather than replaced them.

Apparent domestic consumption, on a crude steel basis, was at an all-time high of 14.3 million tons. Apparent consumption calculations do not take into account changes in inventory, which toward the end of 1972 were probably down from the beginning of the year. Converted to saleable steel products, consumption amounted to some 10.5 million tons.

Canadian steel prices started to rise toward the end of 1971 and continued to rise on a selective basis during 1972. However, generalization on steel prices can be misleading because there are many products and prices vary greatly, depending on quantity purchased, other conditions of sale, and the highly competitive nature of the industry. World prices rose during the year and in some markets more than in Canada. The upward revaluation of major world currencies in relation to the United States and Canadian currencies, particularly the Japanese yen and the German mark, decreased the competitiveness of steel from those countries in North American markets.

Profits for most Canadian steel companies were up in 1972 over those for 1971 and for the three major companies net income rose an average of some 10 per cent from 1971 to 1972 but profits as a percentage of sales increased only slightly to 7.9 per cent from 7.8 per cent in 1971.

The Steel Committee of the Economic Commission for Europe (U.N.) held its 40th session in October, 1972. This body conducts studies and publishes reports on all phases of the world's steel industry. Current projects include: short- and medium-term trends in the steel market; production and use of steel tubes; long-term prospects for steel production, consumption and trade; and distribution and marketing of steel products. In 1972, the Committee conducted a seminar in Romania on direct reduction of iron ore. Czechoslovakia was host to a study tour for members of the Committee following the 40th session; West Germany will host a study tour in 1973. The Committee will conduct a symposium on "The Use of Steel in Motor-Vehicle Manufacture" in Paris, France, from May 6 to 10, 1974.

The Commission also publishes a steel market survey each year that can be purchased from United Nations publications distributors. The most recent survey published in October 1971, ST/ECE/STEEL/40 U.N. Sales No. E72. II.E/M.M.14 summarizes events in 1971 and reviews prospects for 1972.

World Production

After a one-year hiatus in 1971, when world steel production declined from the previous year after 12 consecutive years of increased production, production again increased in 1972 to a record 688 million tons, a remarkable 7.5 per cent increase that few predicted at the end of 1971.

The United States steel industry continued with important gains in the reversal of a downward trend; monthly shipments rose steadily since August 1971 when they had reached a 30-year low. In 1972, imports were down some 10 per cent from 1971 and the domestic industry's shipments were up about 7 per cent. Consumption of steel mill products in the United States in 1972 was approximately 104 million tons. A further increase of about 5 per cent was forecast for 1973 with the largest increases expected to be in steel consumed in the production of capital goods, including machinery, farm equipment, trucks, and freight cars.

* Crude steel includes ingots, continuous cast sections, and steel castings.

** The net tons of 2,000 pounds is used throughout, unless otherwise indicated (net tons x 0.9072 = metric tons).

Japan's economy, suffering from a recession that began in autumn 1970, started a gradual recovery in the second quarter of 1972. Domestic steel consumption in 1972 was 76 million tons in terms of crude steel, which would be above that in 1971, but slightly lower than the high of 77 million tons in 1970. Domestic demand for 1973 was forecast at 81 million tons, an increase of 9 per cent from 1972. Present capacity plus facilities already under construction are considered sufficient to meet steel requirements to 1975, which are now expected to range from 132 to 143 million tons a year by 1975. Earlier forecasts

Table 1. Canada, general statistics of the domestic primary iron and steel industry, 1970-72

	1970[r]	1971	1972[p]
Production			
Volume Indexes			
Total Industrial Production 1961=100	175.5	183.2	194.7
Iron and Steel Mills[1], 1961=100	176.2	179.8	191.0
	($ Million)	($ Million)	($ Million)
Value of Shipments, Iron and Steel Mills[1]	1,691.7	1,745.3	1,906.7
Value of unfilled orders, year-end, Iron and Steel Mills[1]	182.5	244.8	284.9
Value of Inventory owned, year-end, Iron and Steel Mills[1]	359.2	367.3	424.6
Employment, Iron and Steel Mills[1]	(Number)	(Number)	(Number)
Administrative	9,814	9,463	9,700
Hourly rated	39,255	37,752	38,200
Total	49,069	47,215	47,900
Employment index, all employees 1961=100	137.6	136.8	139.0
Average hours per week, hourly rated	40.2	39.9	40.2
	($)	($)	($)
Average earnings per week, hourly rated	155.42	169.55	182.91
Average salaries and wages per week, all employees	163.82	176.38	192.28
Expenditures, Iron and Steel Mills			
Capital	($ Million)	($ Million)	($ Million)
on construction	39.7	32.6	28.2
on machinery	168.2	169.0	165.0
Total	207.9	201.6	193.2
Repair			
on construction	10.5	12.4	13.6
on machinery	168.1	184.6	194.2
Total	178.6	197.0	207.8
Total Capital and Repair	386.5	398.6	401.0
Trade, Primary Iron and Steel[2]			
Exports	382.4	345.2	342.1
Imports[3]	362.0	423.5	457.9

Source: Statistics Canada.
[1]S.I.C. Class 291 – Iron and Steel Mills: covers the production of pig iron, steel ingots, steel castings and primary rolled products, sheet, strip, plate etc. [2]Includes pig iron, steel ingots, steel castings, semis, hot and cold-rolled products, pipe and wire. Excludes sponge iron, iron castings and cast iron pipe—compilation by Mineral Resources Branch. [3] There were negligible imports of pig iron in 1970 and 1971.
[p]Preliminary; [r]Revised.

predicted requirements in 1975 in the order of 165 million tons of steel ingots a year.

The communist bloc countries reported a substantial growth in their national economies. Unlike the rest of the industrialized world the communist bloc countries did not experience a reduced demand for steel in 1971. Crude steel production for the U.S.S.R. was 137.8 million tons in 1972, up about 4 per cent from 1971; growth was expected to continue at approximately the same rate in 1973. U.S.S.R. economists are expecting that some time during the next three or four years there will be a spectacular increase because of the development of consumer products. Other countries in the east European communist bloc expect growth in demand for steel to continue at about the same rate of 3-4 per cent a year through 1973 and 1974.

Canadian primary iron and steel industry*

Pig iron is made at seven plant locations in Canada and steel is made at thirty seven, but only fourteen produce 100,000 tons or more a year. Four companies are integrated and produce both pig iron and steel. The four integrated plants—two at Hamilton, Ontario, and one each at Sault Ste. Marie, Ontario, and Sydney, Nova Scotia—accounted for about 85 per cent of crude steel production and about 90 per cent of pig iron production in 1971.

Pig Iron. Production of pig iron at 9.4 million tons was at an all-time high in 1972, up some 9 per cent over 1971. Pig iron production capacity as of December 31, 1972 was 11.9 million tons of which some 760,000 tons was banked, blown out or idle blast furnace capacity and 810,000 tons was electric furnace capacity.

Crude Steel. Production of crude steel in 1972 at 13.07 million tons was also a record with production exceeding a million tons for every month except October.

Oxygen furnaces produced 5.6 million tons and for the first time exceeded open-hearth production, which declined to 5.2 million tons from 6.3 million tons in 1971. Electric furnace production continued to increase and accounted for some 16.3 per cent of total steel production. Total crude steel production capacity in Canada was 15.54 million tons at the end of 1972; expansion projects under way or planned will raise annual capacity to 16.34 million tons by late 1973.

* A complete listing of Canadian primary iron and steel plants including steel foundries is in the booklet "Operators List 2: Primary Iron and Steel" (75 cents). More detailed statistics are compiled in MR113, "Canadian Primary Iron and Steel Statistics to 1969" (75 cents). Both are available from Mineral Resources Branch or Information Canada.

Steel Pipe and Tube. The Canadian steel pipe and tube industry had an annual capacity of 2,833,500 tons at the beginning of 1973. Capacity has been rising rapidly since the mid-1950's when steel pipe and tube capacity was 414,000 tons a year centred entirely in

Table 2. World production of crude steel, 1970-1972

Countries	1970^r	1971^r	1972^p
	(000 net tons)		
North America, total	148,138	136,825	151,016
Canada	12,346	12,170	13,073
Mexico	4,278	4,212	4,841
United States	131,514	120,443	133,102
South America, total	10,092	11,045	12,032
Western Europe, total	176,348	165,066	179,670
Belgium and Luxembourg	19,918	19,495	22,035
France	26,205	25,198	26,516
West Germany	49,649	44,437	48,176
Italy	19,045	19,238	21,809
Netherlands	5,545	5,603	6,155
Total ECSC	120,362	113,971	124,691
Britain	31,212	26,647	27,910
Other	24,774	24,448	27,069
Eastern Europe, total	174,002	182,703	187,944
Czechoslovakia	12,655	13,299	14,110
Poland	13,001	14,035	14,771
U.S.S.R.	127,717	133,456	138,891
Other	20,629	21,913	20,172
Africa and Middle East, total	5,938	6,135	6,663
Far East, total	132,641	130,658	142,823
China	19,842	23,149	25,353
India	6,917	6,692	7,275
Japan	102,870	97,617	106,830
Other	3,012	3,200	3,365
Australia and other Oceanian	7,520	7,444	7,496
World total	654,679	639,576	687,644

Sources: Canada: Statistics Canada. United States: Annual Statistical Report, American Iron and Steel Institute, and for 1972, Survey of Current Business, March, 1973. Japan: Annual Report Japan Iron and Steel Federation. European Common Market countries: Statistisches Bundesamt, Dusseldorf; Bulletin de la Chambre Syndicale de la Siderurgie Francaise, Jan. 1973. Other western European: Statistisches Bundesamt, Dusseldorf; Metal Bulletin, Jan. 1973. Eastern European countries: Bulletin de la Chambre Syndicale de la Siderurgie Francaise, December (preprint), 1972. Other Far Eastern: Statisches Bundesamt, Dusseldorf; Metal Bulletin, Jan. 1973.
^p Preliminary; ^r Revised.

Table 3. Canada, pig iron production, shipments, trade and consumption, 1970-72

	1970	1971	1972^p
		(net tons)	
Furnace capacity, December 31			
Blast	10,625,000	10,125,000	10,410,000
Electric	710,000	782,000	705,000
Total	11,335,000	10,907,000	11,115,000
Production			
Basic iron	8,275,191	7,835,632	8,510,470
Foundry iron	810,764	780,124	853,423
Malleable iron	*	*	*
Total	9,085,955	8,615,756	9,363,893
Shipments			
Basic iron	51,511	47,883	53,042
Foundry iron	803,637	709,545	895,502
Malleable iron	*	*	*
Total	855,148	757,428	948,544
Imports			
Net tons	96	670	4,125
Value ($ 000)	9	39	177
Exports			
Net tons	642,797	549,454	688,982
Value ($ 000)	35,320	32,767	38,316
Consumption of pig iron			
Steel furnaces	8,063,315	7,676,289	8,362,780
Iron foundries	289,939	279,384	293,287
Consumption of iron and steel scrap			
Steel furnaces	5,940,659	6,226,859	6,616,320
Iron foundries	869,441	1,070,664	1,111,915

Source: Statistics Canada, Primary Iron and Steel (monthly); Iron and Steel Mills (annual); Iron Castings and Cast Iron Pipe and Fittings (monthly).
^{p}Preliminary; *Included under "Foundry iron".

Quebec and Ontario. Developments since then have resulted in one half of the domestic capacity being installed in western Canada to serve, primarily, the petroleum and natural gas industries.

Steel pipe and tube production established a new record in 1972 of 1,295,064 tons up 17 per cent from the previous record of 1971. Big-inch pipe line (20-inch diameter and larger) construction totalled 1,060 miles in 1972. Projections for 1973 indicate construction of slightly less big-inch pipe line. The total of big-inch and little-inch construction in 1973 is not expected to be much over 6,000 miles, down from 7,100 miles in 1972.

The Steel Company of Canada, Limited (Stelco) is the largest manufacturer of steel pipe and tube in Canada. Page-Hersey Tubes, Limited and Stelco formed Welland Tubes Limited as a joint venture in 1955. Camrose Tubes Limited was similarly incorporated in 1959. Stelco acquired Page-Hersey in 1964 and, consequently, full ownership of Welland Tubes Limited and Camrose Tubes Limited.

With extensive pipe and tube making plants at Welland, Ontario, and Camrose, Alberta, Stelco operates 13 pipe and tube mills at five locations and accounts for over 40 per cent of domestic capacity.

Canada's second largest producer of pipe and tube

Table 4. Canada, crude steel production, shipments, trade and consumption, 1970-72

	1970	1971	1972^p
		(net tons)	
Furnace capacity, December 31			
Steel ingot			
Basic open-hearth	6,970,000	5,380,000	5,830,000
Basic oxygen converter	4,400,000	6,690,000	6,730,000
Electric	2,294,450	2,961,600	2,977,800
Total	13,664,450	15,031,600	15,537,800
Steel castings	418,925	429,525	436,525
Total furnace capacity	14,083,375	15,461,125	15,974,325
Production			
Steel ingot			
Basic open-hearth	6,906,492	6,330,838	5,164,585
Basic oxygen	3,617,985	3,934,965	5,601,287
Electric	1,629,935	1,698,429	2,125,934
Total	12,154,412	11,964,232	12,891,806
Continuously cast in total	1,398,463	1,393,724	1,535,761
Steel castings[1]	191,720	205,320	181,067
Total steel production	12,346,132	12,169,552	13,072,873
Alloy steel in total	1,053,856^r	1,046,502	1,200,946
Shipments from plants			
Steel ingots	507,413	496,379	454,228
Steel castings	181,952	200,037	174,027
Rolled steel products	9,084,605	9,220,748	9,829,866
Total	9,773,970	9,917,164	10,458,121
Exports[2], equivalent steel ingots	2,299,201	2,130,320	2,126,290
Imports[2], equivalent steel ingots	2,189,320	3,136,105	3,355,164
Indicated consumption, equivalent steel ingots	12,236,251	13,175,337	14,301,747

Source: Statistics Canada.
[1]Includes basic open-hearth and electric. [2]Computed by Mineral Resources Branch.
^{r}Revised; ^{p}Preliminary.

is Canadian Phoenix Steel Pipe Ltd. with plants at Toronto, Edmonton, Calgary, and at Port Moody, British Columbia.

In 1971, The Algoma Steel Corporation, Limited leased the Mannesmann Tube Company, Ltd.'s seamless pipe and tube plant at Sault Ste. Marie, Ontario, for a period of 15 years. Algoma has an option to purchase the plant from the sixth year of the lease. This adds oil well casing, transmission line pipe, standard pipe, mechanical tubing and couplings to Algoma's range of steel products.

A new concept in Canadian pipemaking was introduced in 1971 with the establishment of International Portable Pipe Mills Ltd. near Calgary. The plant is entirely self-contained and can be moved. Limited trial production runs began late in 1972. The rated capacity is 200,000 tons per year of 42- to 48-inch pipe. The process uses plate and produces a submerged arc welded pipe with a longitudinal seam. Dominion Foundries and Steel, Limited and Alberta Gas Trunk Line Company Limited are major shareholders in this project.

Outlook and forecast

The Canadian economy in 1972 was favourable for increasing the demand for most steel products and general indications were that the economic expansion trend will continue in 1973. By mid-1972, capital expenditures on new construction and equipment were running ahead of expenditures for 1971 by some

Table 5. Canada, production, trade and apparent consumption of crude steel, 1963-72

	Crude Steel Production	Imports[1]	Exports[1]	Indicated Consumption[2]
	(000 net tons equivalent ingots)			
1963	8,190	1,295	1,369	8,116
1964	9,128	2,135	1,485	9,778
1965	10,068	2,892	1,235	11,725
1966	10,020	2,096	1,290	10,826
1967	9,701	1,981	1,368	10,314
1968	11,198	1,884	2,079	11,003
1969	10,048	2,935[r]	1,423	11,560[r]
1970	12,346	2,189	2,299	12,236
1971	12,170	3,136	2,130	13,176
1972[p]	13,073	3,355	2,126	14,302

Source: Statistics Canada.
[1] From Trade of Canada, adjusted to equivalent crude steel by Mineral Resources Branch. [2] Production plus imports less exports with no account taken for stocks. [p] Preliminary; [r] Revised.

7 per cent. A survey conducted by the Department of Industry, Trade and Commerce in October 1972 of 200 companies in manufacturing, mining, oil and gas, electric utilities, and transportation and communications showed that expenditures should be up again some 9 per cent in 1973. It is not expected that this same high rate of increase will be achieved by government departments, and by institutional and commercial services but the review by Statistics Canada* indicated that total capital expenditures by all sectors will be in the order of $23,753 million in 1973. Expenditures for 1972 were about $21,877 million. Therefore, economic forecasts of activities support the prediction that demand for steel products in 1973 will reach an all-time high.

Trade

Domestic shipments of rolled steel products were up for almost all categories over those for 1971. The most notable gains were in shipments to the following

* Private and Public Investment in Canada, Outlook 1973 and Regional Estimates, Statistics Canada, Catalogue No. 61-205 annual.

Table 6. Canada, net shipments of rolled steel products, by type 1970-72

	1970	1971	1972[p]
		(net tons)	
Hot-rolled products			
Semis	503,817	448,723	323,935
Rails	353,225	297,618	170,176
Wire rods	568,569	611,396	690,256
Structurals			
Heavy	618,858	557,592	636,597
Light	137,293	144,220	151,696
Bars, concentrate Reinforcing	730,755	755,645	707,126
Bars, other hot-rolled	807,834	799,877	894,165
Tie plate and track material	91,765	83,765	67,664
Sheet and strip	1,717,006	1,871,037	2,279,105
Plates	1,255,400	1,174,222	1,285,260
Total	6,784,522	6,744,095	7,205,980
Cold-rolled products			
Bars	67,391	68,799	82,334
Sheet, tin mill			
Blackplate and tinplate	1,602,132	1,698,388	1,753,436
Galvanized sheet	630,560	709,466	788,116
Total	2,300,083	2,476,653	2,623,886
Total shipments	9,084,605	9,220,748	9,829,866
Alloy steel in total shipments	561,336	525,425	565,110

Source: Statistics Canada, Primary Iron and Steel (monthly).
[p] Preliminary.

Table 7. Canada, net shipments of rolled steel products (carbon and alloy) to consuming industries, 1970-72

	1970	1971	1972[p]
Automotive and aircraft	855,793	1,105,710	1,328,057
Agricultural equipment manufacturers	140,565	134,509	201,440
Construction	1,577,876	1,514,133	1,652,674
Containers	515,604	529,845	533,269
Machinery and tools	297,963	300,751	310,345
Wire, wire products and fasteners	559,735	584,263	692,189
Resources and extraction	210,295	194,638	197,515
Appliances, utensils, stamping, pressing	591,053	693,428	749,610
Railway operating	405,677	331,591	213,548
Railway cars and locomotives	124,080	108,336	131,987
Shipbuilding	59,544	52,906	55,285
Pipes and tubes	1,121,276	1,161,746	1,261,453
Wholesalers and warehouses	1,232,869	1,229,124	1,261,156
Miscellaneous	64,581	61,604	66,940
Total	7,756,911	8,002,584	8,655,468
Direct exports[1]	1,327,694	1,218,164	1,174,398
Total	9,084,605	9,220,748	9,829,866

Source: Statistics Canada, Primary Iron and Steel (monthly).
[1]Does not include exports by nonproducers, nor ingots and castings.
[p]Preliminary.

industries: agricultural equipment, up 50 per cent; construction, 28 per cent; automotive, 20 per cent; and wire products, 19 per cent. Deliveries to the natural resources and extraction industries were about the same as in 1971 and to the railway operating industry (other than cars and locomotives), down some 55 per cent.

Although imports exceeded exports by a considerable margin during the first half of the year, the rate of imports declined in the second half of the year, particularly in the fourth quarter. There were several reasons for the fourth-quarter decline in imports; probably the most important was competition from domestic steel producers as foreign producers, particularly the Japanese, became increasingly affected by rising production costs and currency revaluation. In addition, a general world wide improvement in demand removed many exports from international markets. There are good reasons to expect these conditions will prevail through 1973 and prospects are good that Canadian exports of primary iron and steel products will exceed imports both in tonnage and in value. Canadian exports to the United States would be adversely affected if the United States decides to increase the number of countries with which it has voluntary restraint agreements on steel imports and/or extends the so-called specialty metals amendment to include carbon steel. However, the United States has always been a net benefactor in its steel trade with Canada, which should justify the exclusion of imports from Canada from these restraints. At the end of 1972 the specialty metal amendments discriminated against Canadian producers of specialty metals and it is hoped that some of these restrictions will be modified.

The United States continued to be Canada's most important customer for steel products, followed by Latin America, Britain and the European Coal and Steel Community (ECSC). The United States again was the major source of imports, being replaced by Japan only in 1971. Imports from the ECSC have increased sharply in recent years, from $194 million in 1970 to $536 million in 1972.

Raw materials

Consumption of raw materials in the manufacture of steel was at an all-time high as suggested by the record production. International iron ore prices remained more or less stabilized through 1972. Currency realignments and the low level of world shipping rates reduced the delivered cost to Japan and Europe. A rise in lake freight rates, after the Lake Erie base price for 1972 was set, increased the cost to buyers in the Great Lakes market. For 1973, Japanese ore prices should be stabilized because of long-term contracts; European prices will be mixed, with most ores priced at 1972 levels; and North American prices will increase slightly to reflect higher production and transportation costs. The cost of additives such as manganese, chromium

Table 8. Canada, trade in steel castings, ingots and rolled products, 1970-72

	Imports			Exports		
	1970	1971	1972p	1970	1971	1972p
	(net tons '000)					
Steel castings	8.8	7.0	11.5	29.1	31.6	22.4
Steel forgings	10.7	12.0	13.0	34.0	16.9	19.9
Steel ingots	44.0	38.9	50.7	76.5	78.6	79.7
Hot-rolled products						
Semis	206.5	238.0	217.4	89.4	123.2	49.8
Rails	7.6	12.9	8.5	81.9	65.8	72.0
Wire rods	161.2	204.2	241.5	127.0	135.8	114.0
Structurals	292.9	306.2	322.9	139.7	148.6	168.2
Bars	110.0	166.1	217.1	176.1	72.4	85.8
Track material	4.2	2.7	1.8	3.5	4.7	8.6
Plates	193.3	278.9	332.7	122.8	164.0	194.2
Sheet and strip	145.9	401.9	433.4	200.1	196.1	263.2
Total hot-rolled	1,121.6	1,610.9	1,775.3	940.5	910.6	955.8
Cold-rolled and other products						
Bars	16.2	14.9	17.4	14.2	11.3	10.6
Sheet and strip cold-rolled	40.1	172.7	160.3	191.1	151.4	119.1
Galvanized	17.4	48.4	51.1	90.4	112.3	105.1
Other*	104.9	99.4	100.4	142.3	135.2	147.1
Pipe	207.6	274.4	257.6	236.4	180.1	136.7
Wire	76.6	76.3	86.4	18.7	28.1	39.3
Total cold-rolled and other	462.8	686.1	673.1	693.1	618.4	557.9
Total rolled products	1,584.4	2,297.0	2,448.5	1,633.6	1,529.0	1,513.7
Total steel	1,647.9	2,354.9	2,523.7	1,773.2	1,656.1	1,635.7

Source: Statistics Canada, Trade of Canada; compilation by Mineral Resources Branch.
*Includes hot-rolled stainless sheet and strip.
pPreliminary.

Table 9. Canada, value* of trade in steel castings, ingots and rolled products, 1970-72

	Imports			Exports		
	1970	1971	1972p	1970	1971	1972p
Steel castings	6,967	5,526	6,963	11,836	11,009	9,268
Steel forgings	11,899	12,042	13,204	18,910	9,660	11,364
Steel ingots	3,594	3,294	3,991	8,240	7,724	8,306
Rolled products						
Hot-rolled	176,812	214,007	237,182	149,980	142,433	138,293
Cold-rolled and other	162,692	188,597	196,428	158,142	141,567	136,556
Total rolled	339,504	402,604	433,610	308,122	284,000	274,849
Total steel	361,964	423,466	457,768	347,108	312,393	303,787

Source: Statistics Canada, Trade of Canada.
*The values in this table relate to the tonnages shown in Table 8.
pPreliminary.

Table 10. Canada, trade in steel by country, 1970-72[1]

	Imports from			Exports to		
	1970	1971	1972^p	1970	1971	1972^p
	(net tons '000)					
United States	799.7	785.2	835.7	1,222.5	1,294.0	1,236.0
Britain	143.4	164.0	175.8	80.2	43.5	63.3
ECSC[2] countries	194.2	364.2	536.2	84.2	41.7	62.9
Other European[3]	107.9	146.4	162.7	109.1	12.2	59.5
Africa	0.9	0.2	6.0	10.5	7.2	3.9
Japan	391.3	886.4	775.1	0.3	0.5	0.2
Other Asian	2.3	2.1	1.6	27.1	44.0	34.2
Latin America	0.2	–	3.5	190.8	172.7	142.8
Middle East	–	–	–	10.1	15.3^r	12.8
Oceania	8.0	6.4	27.1	38.4	25.0	20.1
Total	1,647.9	2,354.9	2,523.7	1,773.2	1,656.1^r	1,635.7

Source: Statistics Canada, Trade of Canada; compilation by Mineral Resources Branch.
[1]Products included are those listed in Table 8. [2]European Coal and Steel Community (ECSC). [3]Includes the U.S.S.R. and Satellites.
^{p}Preliminary; – Nil; ^{r}Revised.

molybdenum, and columbium remained more or less stable in 1972 and will probably experience only moderate increases in 1973. Coking coal prices are expected to continue to rise in the early part of 1973, but unless the production rate for steel exceeds all expectations, the completion of recent coking coal production expansion programs will stabilize the market. In Canada, coking coal prices rose about 12 per cent from 1971. Energy costs will continue to increase over the next decade and will probably become a critical factor in steel production costs; pollution abatement and environmental costs will also be of increasing consequence to the steelmaker.

Steel scrap remained in adequate supply in Canada throughout the year. Demand was high, but the lack of export markets kept the price within the moderate range of between $30 and $33 a ton in the Toronto-Hamilton area for #1 heavy melting. However, late in the year scrap became scarce in the Montreal area and prices ranged up to $38 a ton. With export demands increasing for 1973, prices will undoubtedly be higher in 1973.

Steel prices

The cost of producing steel continued to rise in all major steel-producing countries and this increase was reflected in higher steel prices. According to producers, all the increased costs have not yet been reflected in higher steel prices, which, with an expected increased demand for steel in 1973, will undoubtedly result in further price increases.

Canadian prices for most steel products increased in mid-September and further increases were announced to take effect January 1, 1973. Hot rolled bars and shapes increased 2.1 per cent and plate products 4 per cent. In the United States, where price increases for steel products must be authorized by the Federal Price Commission, steel prices remained fairly stable throughout the year. Late in 1972, some major producers announced price increases in a limited product span to be effective early in 1973 and at the same time the largest producer rescinded an earlier reduction of $25 a ton on merchant bars. If the price hikes stand they will represent an average of 2.7 per cent related to the total product line. Increases included $12 a ton on quality bars, $8 a ton on standard structurals, and $7 a ton on plates.

In Europe, according to the American Metal Market, December 13, 1972, fob Antwerp, the price in dollars per metric ton in November for wire rod was $128 a ton, up $5 from mid-year; for merchant bars it was $123 up $6 from mid-year; and for plates it was $126, down $4 from mid-year. However, the consensus is that prices for European steel prices will be up in 1973 and the level of prices quoted for opening of navigation on the St. Lawrence Seaway indicates a higher demand in Europe, which, in turn, implies lower exports to Canada and the United States.

Investment and corporate development

Capital and repair expenditures in the Canadian iron and steel industry for 1972 amounted to some $453 million compared with $445 million expended in 1971. Grouped in this total are expenditures by iron and steel mills, steel pipe and tube mills, and iron foundries. Year-end reports indicate that most of the expenditures were made or are at least firmly committed; some expenditure commitments were increased. Early indications are that capital and repair expenditures for 1973 will amount to $513 million.

The Algoma Steel Corporation, Limited will complete installation of its new (No. 2) basic oxygen steel plant in April 1973. This plant will provide the capacity to increase annual raw steel production to approximately 4.0 million tons a year when other major facilities in Algoma's expansion program are completed. A second plant to produce burnt lime for the new LD oxygen steel plant will also be completed in early 1973. Work continued on the company's new central screening facilities, scheduled for completion in 1974, that will improve the uniformity in size of raw materials used in the blast furnaces. During 1972, Algoma began construction on a new blast furnace (No. 7), scheduled for completion in late 1974, that will produce 1.8 million tons of pig iron a year. Algoma also announced that work would begin on two major projects in 1973. The first of these is a new coke oven battery (No. 9) that will replace an older battery nearing the end of its life. It will also add to cokemaking capacity now required for greater pig iron production from blast furnaces. The second, a new two-strand continuous slab casting plant will have a capacity of 750,000 tons of product a year. Both these units are expected to be in operation by the end

Table 11. Canada, consumption of raw materials at pig iron and integrated steel plants, 1972

	In Iron and Steel Furnaces		
	Pig Iron Furnaces[1]	Steel Furnaces	Total in Furnaces
		(net tons)	
Iron ore			
Crude and concentrate	2,614,870	52,213	2,667,083
Pellets	10,016,248	190,498	10,206,746
Sinter	2,939,346	–	2,939,346
Total iron ore	15,570,464	242,711	15,813,175
Contained iron	9,120,737	162,138	9,282,875
Other iron-bearing materials			
Scale, sponge iron etc.	278,931	441	279,372
Total	278,931	441	279,372
Contained iron	131,958	265	132,223
Other materials			
Ferromanganese	11,098	81,796	92,894
Scrap			
Own make	88,667	3,091,977	3,180,644
Purchased	112,498	813,559	926,057
Total	201,165	3,905,536	4,106,701
Coke	4,633,546		4,660,821*
Stone			
Limestone	432,878	288,553	721,431
Dolomite	475,127	67,134	542,261
Total	908,005	355,687	1,517,140*
Burnt stone			
Lime	–	363,005	363,005
Dolomite	–	143,571	143,571
Total		506,576	506,576

Source: Company data supplied to Mineral Resources Branch. [1] Blast and electric furnaces. – Nil; . . Not available; *Includes material used in sinter plants.

Table 12. Canada, energy and reductant consumption in major integrated steel plants, 1972

	Coal	Coke	Coke Oven Gas	Tar and Pitch	Natural Gas	Fuel Oil	Oxygen	Electricity
	(net tons)	(net tons)	Mill Ft^3	(000 imp. gal.)	Mill Ft^3	(000 imp. gal.)	Mill Ft^3	Mill kWh
In coke ovens[1]	6,805,711	–	. .	–	. .	. .	–	60.0
In sinter plants	. .	. .	. .	–	. .	. .	–	. .
In blast furnaces	. .	4,633,546	3,707	. .	8,100	42,662	1,582	95.1
Steel furnaces	. .	. .	3,913	. .	–	51,140	16,604	417.5
Other uses	4,273	25,984	60,262	–	19,180	65,859	2,660	2,104.0
Total consumption	6,809,984	4,659,530	67,882	7,449	27,280	159,661	20,846	2,676.6

Source: Data supplied by companies to Mineral Resources Branch.
[1]Includes coal used by Devco which took over Sysco coke ovens, May 1, 1968.
– Nil; . . Included in total; publication would disclose individual company data.

of 1975. Cannelton Industries, Inc., an Algoma subsidiary, built a plant near Sault Ste. Marie, Michigan, in 1972 for threading, attaching couplings, and testing seamless tubes.

Dominion Foundries and Steel, Limited (Dofasco) started up its third electrolytic tinning line in March 1972 doubling its tin plate capacity. It also continued work on its six-year environmental control program.

An installation for the clarification of all hot mill cooling waters was completed in 1972. Other programs scheduled for completion by the end of 1973 include the installation of a hydrochloric acid regeneration plant and cold mill water treatment facilities.

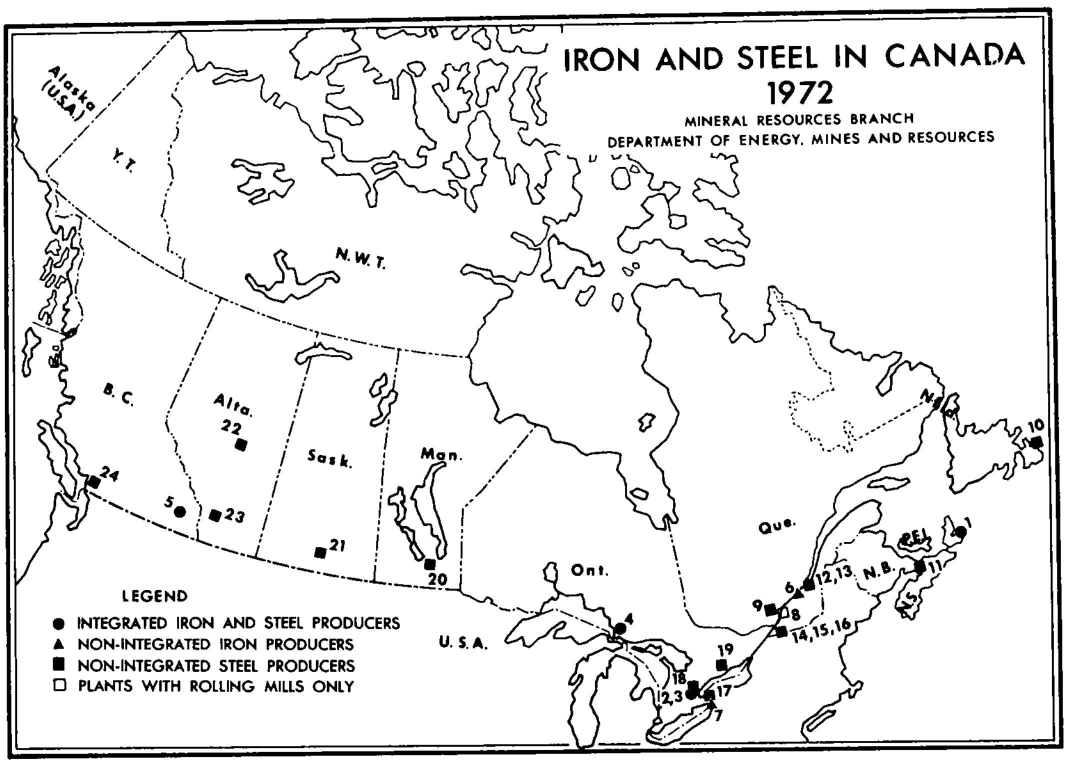
Falconbridge Nickel Mines Limited closed its SL/RN iron-nickel plant because it has been unable to achieve continuous operations in accordance with expectations. Cominco Ltd. closed its electric furnace pig-iron and basis oxygen steel-producing operations at Kimberley, British Columbia. The operations, with capacity to produce 110,000 tons of pig-iron and 80,000 tons of steel a year, were no longer economic.

Lake Ontario Steel Company Limited (Lasco) began the expansion of capacity from 300,000 to 350,000 tpy at its Whitby, Ontario, steel plant. In November, QSP Ltd. announced that Pecor of Canada Ltd. had been given a contract to build a 200,000-ton-a-year (tpy) capacity plant at Longueuil, Quebec. Ivaco Industries Limited plans to build a 150,000 tpy billet plant at L'Original, Ontario.

Interprovincial Steel and Pipe Corporation Ltd. (Ipsco) initiated a program to increase both its steel-producing capacity and rolling capacity, particularly for large-diameter pipe, and the program was largely completed by year-end. It included a third spiral weld unit to boost production from 90,000 tons of pipe a year to 135,000 tons, and a fourth electric furnace to double steel production capacity from 300,000 tons a year to 600,000 tons. The new furnace will begin test trials in January 1973. However, soaking pit capacity will limit crude steel production to 450,000 tpy in 1973 which will be sufficient for the Ipsco's needs. Some 886,000 common shares of Ipsco were purchased by Slater Steel Industries Limited. In November, 1971, British Steel Corporation acquired a 25 per cent interest in Ipsco through its Canadian subsidiary, Stanton Pipes Limited.

Sidbec, the Quebec government steel company that operates the former Montreal and Contrecoeur Works of Dominion Steel and Coal Corporation, Limited, now renamed Sidbec-Dosco Limited, completed the major portions of its improvement and expansion program announced in 1970. The new electric steel plant with 2-100/120 ton electric furnaces (12,500kva each) and 1-6 strand billet caster started operations at Contrecoeur in 1972. The Midrex direct reduction plant with a yearly capacity of 440,000 tons of reduced pellets advanced to the final stages and will start up early in 1973. New roll shops for the hot and cold mills have been completed and put into operation. The revamped shot blast cleaning line has started operation as a combination shot-blast and pickling-line. A new strip welder has been included in this line. Extension of the annealing shop in the cold mill has also been completed and is operative.

The Steel Company of Canada's major expansion program at Hilton Works entered its final stages in 1972 with the start up of the new (No. 7) coke oven battery (83 ovens) and No. 3 Bloom and Billet Mill. Designed to raise production and processing capacity from 4.75 million tons to 6.0 million tons a year, these facilities complement the new basic oxygen steelmaking plant that came on stream in December 1971. The eight furnaces in No. 2 Open-Hearth Shop were phased out during 1972. Other major projects completed at Hilton Works during 1972 were four soaking pits in the slabbing mill and increased finishing capacity at the 148″ plate mill. Equipment schedules for start up in 1973 include slab cooling and handling facilities and two soaking pits at No. 1 Universal Slabbing Mill, conversion of No. 1 Rod Mill to bar production, revamping of the 56″ hot strip mill including a 5th slab-heating furnace, and additional equipment for the BOF Shop to expedite ingot pouring and handling. The large diameter spiral weld pipe mill, capable of producing pipe to 60″ diameter, is expected to be operating in late 1973. Further additions to No. 3 Bloom and Billet Mill are expected to be operating in early 1974. At the Edmonton Works in Alberta, expansion of Grinding Ball production facilities were completed in December 1972. Approval was given for the construction of new steelmaking facilities at both the Edmonton Steel Works and McMaster Works at Contrecoeur, Quebec. Both facilities consist of electric steelmaking furnaces and billet casting equipment. Start up of the new equipment is expected to be in early 1974. In addition to the foregoing, a total of approximately $64 million had been spent or committed on Stelco's environmental control program to the end of 1972.



Integrated iron and steel producers
(numbers refer to numbers on map)

1. Sydney Steel Corporation (Sydney)
2. Dominion Foundries and Steel, Limited (Hamilton)
3. The Steel Company of Canada, Limited (Hamilton)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Cominco Ltd. (Kimberley) – closed in 1972

Nonintegrated iron producers

6. Quebec Iron and Titanium Corporation (Sorel)
7. Canadian Furnace Division of Algoma (Port Colborne)

Plants with rolling mills only

8. The Steel Company of Canada, Limited (Contrecoeur)

Nonintegrated steel producers
(a partial listing)

9. Sidbec-Dosco Limited (Contrecoeur)
10. Newfoundland Steel (1968) Company Limited (Octagon Pond) – closed in 1972
11. Enamel & Heating Products, Limited (Amherst)
12. Atlas Steels Division of Rio Algom Mines Limited (Tracy)
13. Colt Industries (Canada) Ltd. (Sorel)
14. Canadian Steel Foundries Division of Hawker Siddeley Canada Ltd. (Montreal)
15. Canadian Steel Wheel Limited (Montreal)
16. Sidbec-Dosco Limited (Montreal)
17. Atlas Steels (Welland)
18. Burlington Steel Division of Slater Steel Industries Limited (Hamilton)
19. Lake Ontario Steel Company Limited (Whitby)
20. Manitoba Rolling Mills Division of Dominion Bridge Company, Limited (Selkirk)
21. Interprovincial Steel and Pipe Corporation Ltd. (Regina)
22. Premier Works of Stelco (Edmonton)
23. Western Canada Steel Limited (Calgary)
24. Western Canada Steel Limited (Vancouver)

Canada, tariffs on selected iron and steel materials.

Item No.		British Preferential	Most Favoured Nation	General
32905-1	Iron ore	Free	Free	Free
37301-1 37302-1 37303-1	Iron and steel scrap	Free	Free	Free
37400-1	Pig iron, nop,per ton	Free	Free	$2.50
37600-1	Sponge iron	Free	Free	Free
37700-1	Ingots of iron or steel, nop, per ton	Free	Free	$5.00
37800-1	Iron or steel, semifinished, namely: blooms, slabs, billets, or sheet bars	Free	5%	10%
37900-1	Bar or rods, hot-rolled	5%	10%	20%
37905-1	Bars or rods, cold-rolled	5%	12½%	25%
37915-1	Rods for wire manufacture, per ton	Free	$3.00	$5.00
37920-1	Rods for fencing wire manufacture, per ton	Free	Free	$5.00
37950-1	Shapes or sections of iron or steel, nop, not further manufactured than extruded or drawn	10%	12½%	35%
38001-1	Angles, beams, channels, tees, zees and other shapes or sections, nop	5%	10%	20%
38002-1	Large sections, not made in Canada, per ton	Free	$5.00	$20.00
38100-1		5%	10%	20%
38105-1	Plate, flanged or dished	5%	15%	30%
38110-1	Plate, or iron or steel, nop sheet or strip	5%	12½%	25%
38201-1	Sheet or strip hot-rolled	5%	10%	20%
38202-1	Sheet or strip cold-rolled	5%	12½%	25%
38203-1	Sheet or strip coated with tin or enamel	10%	12½%	25%
38204-1	Sheet or strip coated with zinc	7½%	12½%	25%
38205-1	Sheet or strip coated, nop	7½%	12½%	20%
38400-1	Skelp (plate, sheet strip, hot- or cold-rolled for mfg. pipe, tubes)	Free	7½%	15%
38700-1	Rails	5%	10%	20%
39000-1	Castings, rough, nop	15%	15%	27½%
39005-1	Piston ring castings, rough	Free	Free	27½%
39101-1	Ingot moulds for steel production	Free	Free	Free
39102-1	Ingot moulds, nop	Free	7½%	10%
39200-1	Forgings	15%	17½%	30%
39900-1	Pipes, large diameter	10%	15%	30%
40101-1	Wire, round, nop	2½%	7½%	20%
40102-1	Wire, other, nop	5%	10%	20%
40103-1	Wire, coated or covered, nop	5%	10%	20%

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Further details and specific variations may be obtained from the above authority.
NOP Not otherwise provided for.

Lead

M. GAUVIN

In 1972 Canada's production of lead, based on lead recovered from domestic ores and concentrates and the recoverable lead content of ores and concentrates exported was estimated at 371,332 short tons*, a reduction of 8.4 per cent from 1971. Because of higher prices, the value of Canadian lead production in 1972 was some $5.1 million greater than that of 1971. Most of this reduction was recorded in British Columbia and New Brunswick. The total mine output of lead, expressed as the lead content of domestic ores and concentrates produced was estimated at 414,752 tons compared with 435,168 tons in 1971. Labour strikes at Cominco Ltd. from July 8 to July 24 and at Heath Steele Mines Limited from July 1 to August 29, the suspension of operations at Nigadoo River Mines Limited on January 4 following a labour dispute, and the permanent closure of Dresser Minerals Division of Dresser Industries, Inc. contributed to the total drop in production. Two new mines began operating in 1972. The Sturgeon Lake, Ontario, mine of Mattabi Mines Limited with ore reserves of 12.8 million tons, averaging 0.84 per cent lead, 7.60 per cent zinc, 0.94 per cent copper and 3.13 ounces of silver a ton, commenced operations in August 1972 at a rate of 3,000 tons of ore a day and produces three concentrates: a copper, a zinc and a lead concentrate. Near Houston, British Columbia, the Bradina mine of the Bradina Joint Venture began operating in March 1972. Its mill, with a rated capacity of 600 tons a day, produces a copper concentrate and a combined lead-zinc concentrate. Bradina's proven and probable ore reserves at the end of 1972 totalled 438,300 tons averaging 1.67 per cent lead, 6.30 per cent zinc, 0.59 per cent copper, 7.96 ounces of silver and 0.09 ounce of gold a ton. Sturgeon Lake Mines Limited announced that it would start construction work in 1973 to bring its Sturgeon Lake orebody into production in 1975. It reports ore reserves of 2.11 million tons grading 1.47 per cent lead, 10.64 per cent zinc, 2.98 per cent copper and 6.10 ounces of silver a ton.

Primary refined lead output totalled 205,978 tons compared with 185,554 tons in 1971. The lead refinery of Cominco Ltd. at Trail, British Columbia, with a capacity of 210,000 tons annually, and that of Brunswick Mining and Smelting Corporation Limited at Belledune, New Brunswick, with an annual capacity of 30,000 tons, remained Canada's only producers of primary lead metal. The Belledune plant is being converted from an Imperial Smelting Process lead-zinc blast furnace to a conventional lead blast furnace processing lead concentrates only, with a capacity of 70,000 tons of refined lead annually.

Most of the lead ores and concentrates from western Canada were treated by Cominco Ltd. at Trail, British Columbia; the remainder were treated at plants in northwestern United States, Europe and Japan. Lead concentrates produced in eastern Canada, excluding that portion of the output of Brunswick Mining and Smelting Corporation smelted at Belledune, were shipped to Trail and smelters in the United States and Europe.

Exports of lead contained in ores and concentrates were 16.7 per cent lower than in 1971 with over 60 per cent going to Japan and most of the remainder shipped to smelters in the United States, West Germany and Belgium. Metal exports in 1972 were almost 3 per cent more than in 1971. The United States and Britain continued to be the major customers. Imports of refined lead metal were 11,520 tons compared with 4,632 tons in 1971.

Canadian consumption of primary and secondary lead metal in 1972 was 70,203 and 42,730 tons, respectively, compared with 60,299 tons of primary and 32,622 tons of secondary lead in 1971.

United States imports and stockpiles

United States imports of lead metal and lead in ores and concentrates totalled 370,000 tons in 1972, about 40 per cent more than in 1971. The increase, which occurred more in metal than in ores and concentrates, resulted mainly from the recovery in the United States economy. The increase in output by United States lead-producing mines, particularly those in the new Missouri lead belt area in southeastern Missouri, resulted in a greater percentage of United States lead smelter capacity being taken up by domestically produced concentrates.

The United States government stockpile at the end of 1971 had a lead inventory of 1.13 million tons which at the end of 1972 had been reduced to 1.08 million tons because of sales by the General Service Administration (GSA). In July 1972, President Nixon approved Public Law 92-356 authorizing the release of an additional 498,000 tons of lead most of which is available for disposal over about 10 years through primary domestic lead producers who have entered

* Wherever used in this review, the term ton refers to the short ton of 2,000 pounds avoirdupois, unless otherwise stated.

Table 1. Canada, lead production, trade and consumption, 1971-72

	1971		1972p	
	(tons)	($)	(tons)	($)
Production				
All forms[1]				
Yukon Territory	108,668	29,340,379	112,960	34,848,000
British Columbia	123,963	33,470,238	93,983	28,994,000
Northwest Territories	83,814	22,629,795	83,000	25,606,000
New Brunswick	65,405	17,659,353	51,874	16,003,000
Newfoundland	13,481	3,639,735	17,250	5,322,000
Ontario	8,915	2,407,177	10,378	3,202,000
Quebec	647	174,632	1,693	522,000
Manitoba	202	54,414	194	60,000
Nova Scotia	415	112,001	–	–
Total	405,510	109,487,724	371,332	114,557,000
Mine output[2]	435,168		414,752	
Refined production[3]	185,554		205,978	
Exports				
Lead contained in ores and concentrates				
Japan	131,551	22,830,000	108,246	21,340,000
United States	24,176	4,222,000	26,148	3,967,000
West Germany	32,922	5,155,000	20,832	2,970,000
Belgium and Luxembourg	16,136	2,351,000	9,806	1,354,000
Britain	2,484	384,000	5,637	888,000
Italy	3,926	452,000	4,986	692,000
Mexico	2,497	233,000	2,358	279,000
Other countries	662	133,000	563	145,000
Total	214,354	35,760,000	178,576	31,635,000
Lead in pigs, blocks and shot				
United States	58,361	13,873,000	75,402	19,242,000
Britain	46,557	10,052,000	49,372	11,544,000
Netherlands	5,682	1,191,000	6,224	1,465,000
India	15,484	3,300,000	3,535	856,000
Italy	6,070	1,277,000	1,543	339,000
West Germany	995	206,000	1,352	307,000
People's Republic of China	–	–	1,157	301,000
Argentina	55	11,000	993	198,000
Hong Kong	121	26,000	324	83,000
Norway	362	75,000	328	78,000
Philippines	355	71,000	239	53,000
Japan	–	–	165	39,000
Other countries	2,842	582,000	207	50,000
Total	136,884	30,664,000	140,841	34,555,000
Lead and lead alloy scrap (gross weight)				
West Germany	329	56,000	7,756	995,000
United States	1,418	266,000	1,206	310,000
Netherlands	522	71,000	1,118	202,000
South Korea	–	–	677	86,000
Belgium and Luxembourg	2,511	605,000	527	80,000

Table 1 (cont'd)

	1971		1972p	
	(tons)	($)	(tons)	($)
Exports (cont'd)				
Britain	205	67,000	264	62,000
Other countries	863	125,000	759	145,000
Total	5,848	1,190,000	12,307	1,880,000
Lead fabricated materials not elsewhere specified				
United States	3,614	1,236,000	6,770	2,216,000
Britain	–	–	58	13,000
Australia	10	5,000	10	5,000
Other countries	133	138,000	7	5,000
Total	3,757	1,379,000	6,845	2,239,000
Imports				
Lead pigs, blocks and shot	4,632	1,294,000	11,520	2,929,000
Lead oxide; litharge, red lead, mineral orange	3,029	825,000	2,380	717,000
Lead fabricated materials not elsewhere specified	371	238,000	324	204,000
Total	8,032	2,357,000	14,224	3,850,000

	1971 Primary	1971 Secondary[4]	1971 Total	1972p Primary	1972p Secondary[4]	1972p Total
		(tons)			(tons)	
Consumption						
Lead used for, or in the production of						
antimonial lead	1,687	19,469	21,156	2,101	29,839	31,936
battery and battery oxides	23,449	2,797	26,246	31,418	2,844	34,262
cable covering	3,333	482	3,815	3,305	440	3,745
chemical uses: white lead, red lead, litharge, tetraethyl lead, etc.	21,116	4,023 (chemical uses and copper alloys combined)	25,258 (chemical uses and copper alloys combined)	22,374	4,566 (chemical uses and copper alloys combined)	27,337 (chemical uses and copper alloys combined)
copper alloys; brass, bronze, etc.	419			397		
lead alloys						
solders	2,252	1,819	4,071	2,213	1,364	3,577
others (including babbitt, type metal, etc.)	183	2,325	2,508	224	2,326	2,550
semifinished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, fail, collapsible tubes, etc.	5,607	554	6,161	5,822	505	6,327
Other	2,253	1,193	3,446	2,349	350	3,199
Total, all categories	60,299	32,662	92,961	70,203	42,730	112,933

Source: Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates exported. [2] Lead content of domestic ores and concentrates produced. [3] Primary refined lead from all sources. [4] Indluces all remelt scrap lead and scrap lead used to make antimonial lead.
*p*Premilinary; – Nil

Table 2. Canada, lead production, trade and consumption, 1962-72

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports, Refined[3]	Consumption[4]
			(tons)				
1962	215,329	152,217	59,495	125,802	185,297	578	77,286
1963	201,165	155,000	53,756	97,144	150,900	1,741	77,958
1964	203,717	151,372	80,357	95,867	176,224	73	82,736
1965	291,807	186,484	106,964	129,065	236,029	71	90,168
1966	300,622	184,871	112,934	106,468	219,402	626	96,683
1967	317,963	193,235	126,194	132,320	258,514	438	93.953
1968	340,176	202,100	143,853	138,781	282,634	152	94,660
1969	318,632	187,143	140,175	107,090	247,265	131	105,915
1970	389,185	204,630	165,912	152,821	318,733	2,199	93,437
1971	405,510	185,554	214,354	136,884	351,238	4,632	92,961
1972[p]	371,332	205,978	178,576	140,841	319,417	11,520	112,933

Source: Statistics Canada.
[1]Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus the estimated recoverable lead in domestic ores and concentrates exported. [2]Primary refined lead from all sources. [3]Lead in pigs and blocks. [4]Consumption of lead, primary and secondary in origin.
[p]Preliminary

into long-term contracts with the United States government. The stockpile objective at the end of 1972 was 530,000 tons of lead. The President's decision in March 1973 to ask Congress for authority to dispose of most of the stockpiled materials held by the government has major implications for exporters to the United States, particularly lead producers. The proposed new stockpile objective for lead is 65,100 tons.

Two bills were introduced into the United States House of Representatives in March 1973 which call for a two-year suspension of the import duty on zinc contained in zinc concentrates and quarterly quotas of 125,000 tons of zinc metal, 40,000 tons of lead metal and 24,000 tons of lead contained in ores and concentrates. Imports up to the quota levels would enter at the current duties and imports above these limits would be subject to a 19 per cent ad valorem duty. Two similar bills were introduced in the previous Congress on which no final action was taken.

World production and consumption

Noncommunist world mine production of lead according to statistics published by the International Lead and Zinc Study Group was 2.81 million tons in 1972, slightly higher than that of 1971. A substantial increase in United States production together with smaller increases in Peru, Yugoslavia and Italy more than offset declines in the other producing countries of the world including Australia and Canada, the world's second and third largest producers. The United States retained its position as the world's leading producer. Noncommunist world production of primary and secondary refined lead totalled an estimated 4.2 million tons, an increase of 740,900 tons over 1971. Increases in the production of refined lead were reported by all producing countries except West Germany, Italy, the Republic of South Africa and Argentina, all of which reported small decreases.

Mine production of lead in the United States rose from 602,600 tons in 1971 to 644,200 tons in 1972 with most of the gain being in Missouri. Production in the State of Missouri represented 79 per cent of the United States mine production of lead. Refined lead produced at primary refineries in the United States totalled 700,893 tons in 1972 compared with 654,392 tons in 1971.

Consumption of lead in the noncommunist world rose in 1972 to a new record high of 3.73 million tons, an increase of 5 per cent from the previous high established in 1971. The United States remained, by far, the world's largest consumer, using 1.43 million tons or some 2,800 tons less than in 1971. In 1972 lead consumption resumed the growth that was a feature of its development in the 1960's and this upward trend is expected to continue in 1973. Although there is now a better economic climate in many countries, lead still faces problems from potential oversupply, possible large United States government stockpile releases and currency realignments. The International Lead and Zinc Study Group forecasts lead production to rise more than consumption in 1973 and there is a possibility of a large surplus developing unless some producers continue to restrain production. Producers' stocks at the end of 1972 are estimated at 270,000 tons compared with 226,000 tons at the end of 1971.

One new smelter began production in 1972. The Ammi Sarda SpA Imperial Smelting Process (ISP) smelter went on stream at Portovesme, Italy and its output is expected to be 40,000 tons of lead bullion a year. Another ISP plant, with annual capacity of 33,000 tons of lead bullion, is planned to commence operations in 1973 at Titor Veles, Yugoslavia.

In 1972 a new open-pit lead mine began operating in Morocco. Two mines expanded their output: one in Australia, and the Trepca mine in Yugoslavia, which expanded from 60,000 to 110,000 tons of lead a year. Two lead-producing mines closed during 1972: the largest with a capacity of 44,000 tons of lead a year was the Federal Mine of St. Joe Minerals Corporation in Missouri, U.S.A., and the other was in Australia. In 1973 four new mines are scheduled to commence production, the largest being St. Joe Minerals Corporation's Brushy Creek mine in Missouri with an operating rate of 50,000 tons of lead a year.

Outlook

Canada's mine production of lead in 1973 is forecast to be some 420,000 tons and, with reasonably stable world economic conditions, is expected to remain close to this figure during the period 1974-77. However, it could easily be affected by policies relating to United States government stockpile releases, final decisions on the allowable lead content in gasoline, and protectionism in the United States.

The lead industry is faced with many problems, the most serious being the proposed regulations concerning the elimination of lead additives from gasoline, one of the metal's major uses, in order to control pollution. In 1972, lead used in antiknock additives in gasoline in the United States increased appreciably, compared with 1971, and represented some 19.5 per cent of total consumption. No significant change in the consumption of lead for additives is expected during the next two years but, if the proposals of the Environmental Protection Agency are put into effect in the United States, the consumption of lead in gasoline in that country can be expected to drop from the current 278,340 tons per year to about 100,000 tons in 1979. If, however, similar regulations are adopted in countries other than the United States the total amount of lead used in gasoline in such countries is not expected to change appreciably because of a

Table 3. Noncommunist world mine production of lead, 1971-72

	1971	1972^p
	(tons)	
United States	602,600	644,200
Australia	428,600	423,700
Canada	427,600	416,000
Mexico	191,500	189,800
Peru	162,500	178,600
Yugoslavia	119,600	124,300
Morocco	86,000	. .
Sweden	85,600	81,900
Republic of South Africa	80,700	65,000
Japan	77,800	70,100
Spain	77,400	74,300
Ireland	56,900	52,900
West Germany	46,700	44,900
Argentina	39,700	38,600
Zambia	37,400	. .
Italy	26,800	35,800
Other countries	251,100	370,800
Total	2,798,500	2,810,900[1]

Source: International Lead and Zinc Study Group, *Monthly Bulletin*, March 1973.
[1]Total includes estimates for those countries for which figures are not available.
[p]Preliminary; . . Not available.

Table 4. Noncommunist world production[1] of refined lead, 1971-72

	1971	1972^p
	(tons)	
United States	1,131,900	1,182,100
West Germany	331,700	299,200
Britain	290,600	294,400
Japan	237,100	246,100
Australia	212,100	228,900
Canada	185,300	197,100
France	174,700	205,900
Mexico	170,500	173,700
Yugoslavia	107,400	. .
Spain	102,300	104,500
Belgium	87,600	102,400
Italy	83,600	75,000
Republic of South Africa	76,900	71,300
Peru	74,400	87,200
Sweden	49,400	54,900
Argentina	48,300	43,700
Other countries	201,800	840,000
Total	3,565,500	4,206,400

Source: International Lead and Zinc Study Group, *Monthly Bulletin*, March 1973.
[1]Total production by smelters or refineries, of refined pig lead, plus the lead content of antimonial lead – including production on toll in the reporting country – regardless of the type of source material, i.e., whether ores, concentrates, lead bullion, lead alloys, mattes, residues, slags or scrap. Remelted pig lead and remelted antimonial lead are excluded.
[p]Preliminary; . . Not available.

projected increase in the use and production of automobiles. The use of lead in many of its historical applications such as type metal, cable sheathing and paints is expected to gradually decline. However, as a basic paint for rust and corrosion protection in structural and highway use, lead is still the preferred base material.

The future of lead in batteries and as a building material appears to be good. The brightest future for the metal still appears to be its use in lead-acid storage batteries, not only for original installation and replacement batteries in the growing output of gasoline-powered vehicles, but also as the power source in the rapidly developing battery-powered passenger vehicle. The slowly developing home and industrial building market could also grow into a major consumer of lead as a soundproofing, waterproofing and decorative material.

World consumption of lead during the next two years is expected to increase at the rate of 2.5 per cent annually, slightly less than the growth rate during the past two years. The United States, which for many years has been Canada's most important foreign lead market, is becoming more self-sufficient. United States mine production rose by 72 per cent during the last five years because of record production from the new lead belt in Missouri. With the increased production, and surplus government stocks of lead which represent an additional source of supply in the United States, a greater part of Canada's exports may have to find outlets in other countries. Although world production of refined lead declined slightly in 1971 it is now rising again and prudence exercised by producers is effectively contributing to a closer balance between supply and demand. Canadian lead exporters will face increasing competition from expanding and new mine output around the world. Lead mine production is forecast to rise more than consumption and a surplus may develop unless some producers continue to restrain production.

Canadian developments

Yukon Territory. Production in the Yukon Territory increased slightly in 1972 compared with 1971. At the lead-zinc-silver property of Anvil Mining Corporation Limited near Faro an increased tonnage of ore was milled. The company announced that it will be expanding its mill to a rated capacity of 10,000 tons a day with the expansion to be completed early in 1974. It also plans to mine a lower grade of ore but produce the same quantity of concentrates. Lead production declined at the silver-lead-zinc property of United Keno Hill Mines Limited near Mayo because of the final depletion of known ore reserves of the Hector and Calumet mines. The Townsite and Dixie adits were being driven to develop ore indicated by diamond drilling. Dynasty Explorations Limited in association with various companies conducted an active exploration program in the Yukon Territory and, in the Hess Mountains area 100 miles east of United Keno Hill, found thick silver-lead Keno Hill-type zones which are being followed up with bulldozing, trenching and diamond drilling. In the Summit Lake area near the Yukon–Northwest Territories boundary, Placer Development Limited has found mineralization over a strike length of 3 miles. Bulldozing has exposed widths of significant mineralization up to 150 feet wide containing bands ranging from 10 to 30 per cent combined lead-zinc separated by lower grade values.

Northwest Territories. Output by Pine Point Mines Limited, 69 per cent owned by Cominco Ltd., at its zinc-lead property near Pine Point on the south shore of Great Slave Lake remained at the same level as that of 1971. The company did some drifting in the M-40 orebody in preparation for testing a continuous mining machine. Pine Point Mines Limited also purchased the claims of Coronet Mines Ltd. in the Pine Point area containing two known orebodies.

A surface diamond drilling program was continued on the Polaris property of Arvik Mines Ltd. on Little Cornwallis Island and was followed by the driving of 5,200 feet of decline and drifts to provide detailed information on the orebody and to establish costs and working conditions involved in mining in this remote location. Ore reserves of at least 20 million tons with a grade of more than 20 per cent combined zinc and lead have been confirmed. Arvik Mines is owned by Cominco Ltd. (75 per cent) and Bankeno Mines Limited (25 per cent).

British Columbia. Cominco Ltd. operated the Sullivan mine in the southeastern part of the province and reopened its H.B. mine near Salmo. The H.B. mine, which had been closed since 1966, began operations early in 1973. Concentrates from these mines, from Pine Point Mines Limited and from custom suppliers were treated at Cominco's metallurgical works at Trail, which include a lead smelter and refinery.

New Brunswick. The base-metal property of Brunswick Mining and Smelting Corporation Limited near Bathurst continued to be the principal lead producer in New Brunswick. Conversion of the company's Imperial Smelting Process (ISP) lead-zinc smelter at Belledune to a smelter treating only lead concentrates began in January 1972 and is scheduled to be completed before mid-1973. Its rated annual capacity will then be 70,000 tons of refined lead a year. In the No. 12 mine the change-over to a mechanized cut-and-fill mining method continued. Work also continued throughout the year on the installation of permanent facilities designed to isolate the gases from burning sulphides in an old stoping area from the active mine workings and exhaust the gases to surface. Modifications to increase hoisting capacity from 5,000 to 6,500 tons a day were completed in January 1973.

At Heath Steele Mines Limited near Newcastle construction of a surface plant was begun for the new No. 5 shaft, sinking of which will begin in 1973. Construction of an addition to the mill is scheduled to commence in 1973 and will increase mill capacity from 3,000 to 4,000 tons a day by 1976.

In November 1971 Anaconda Canada Limited suspended mining operations of the copper ore zone of its Caribou property because of metallurgical difficulties. During 1972 the company continued an active research program to solve the metallurgical problems that also forced the company to stop development work at its main Caribou zinc-lead-copper-silver deposit.

Newfoundland. American Smelting and Refining Company, Buchans Unit, was again the only lead producer in Newfoundland. The company operates a 1,250 ton-a-day mill at Buchans in the central part of the province and produces lead, zinc, copper and precious metal concentrates.

Nova Scotia. Dresser Minerals Division of Dresser Industries, Inc. at Walton, Nova Scotia, announced permanent closure of its property in August 1972 after mining operations had been suspended by flooding of the mine in October 1971. The company, whose main product was barite, had been in production since 1941 and mined a lead-silver deposit that underlies the barite zone.

Lead in gasoline

The automobile was first seriously considered as a source of atmospheric pollution in the late 1940's in California because of its emission of carbon monoxide, unburnt hydrocarbons and oxides of nitrogen. Reactions between unburnt hydrocarbons and oxides of nitrogen produce ozone and other oxidants which cause photochemical smog to form in special atmospheric conditions. This smog causes irritation of the eyes and respiratory system, damages crops and vegetation, attacks rubber and reduces visibility. Some components of automotive exhausts, such as polynuclear aromatic and phenolic compounds, are suspected of being cancer-producing and cancer-accelerating agents. Recent concern has centred on the use of lead in gasoline, which many claim has already brought or will bring the amount of lead in the atmosphere up to levels that might constitute a hazard to public health. The results of studies carried out to date tend to indicate that there is no demonstrable relationship between the concentration of lead in the air of main cities and the concentration of lead in the blood of individuals living in those areas.

Lead antiknock additives, tetraethyl lead (TEL) and tetramethyl lead (TML), are widely used in motor fuels to increase their resistance to knock. TEL and TML have different physical properties and lead content but their antiknock behaviour is determined principally by their lead content. The antiknock quality of gasoline is measured by a scale of research octane numbers (RON). Nearly all grades of gasoline contain lead, the amount added depending on the quality of the base stock of the fuel and the final octane rating required. Efficient high compression internal combustion engines now require a fuel with a high RON number.

The Clean Air Act of 1970 in the United States requires that by 1975 automotive emissions of hydrocarbons and carbon monoxide be reduced to about 10 per cent of their 1971 level and that by 1976 the oxides of nitrogen be reduced to about 10 per cent of their 1971 level. Some doubt exists as to whether these particular standards will eventually be enforced. Automobile manufacturers have now been given an extension of one year to meet these standards. Compliance with these stringent regulations will be costly to the consumer because of the changes required in the design of engines and exhaust systems. Lead would have to be eliminated from gasoline if catalytic converters, the currently favoured method to reduce emissions, are to be used. More important, authorities seem to agree that this will substantially increase fuel consumption, which is causing concern in the light of the mounting energy crisis in the United States.

Regulations similar to the Clean Air Act in the United States have been formulated by other industrialized countries of the world including Canada. Canada had decided to adopt the same stringent emission controls for 1975 domestic cars as those planned for 1975 U.S. automobiles. However with the one-year postponement of the 1975 standards and with uncertainty as to what standards will eventually apply in the United States the Canadian government has announced that it will follow the United States only until the 1975 standards and not go further for the time being.

Uses

Lead has many useful chemical and mechanical properties and because of this versatility it has a variety of industrial applications. It is soft, ductile, alloys readily with other materials, has good corrosion resistance, a high boiling point, a low melting point and a high specific gravity. Lead is one of the oldest metals known to man and since medieval times has been used in piping, building materials, solders, paint, type metal, ammunition and castings.

Lead is used mainly in lead-acid storage batteries, the bulk of which is used for starting, lighting and ignition (SLI) in automobiles and trucks. Recent improvements in battery manufacture have significantly reduced the weight of lead per battery unit and increased the average battery life and performance. However, lead usage in SLI batteries is expected to continue to grow. This growth will be added to by the rapid expansion in the use of electrically powered industrial trucks. The growth in manufacturing of the

Table 5. Principal lead (mine) producers in Canada, 1972 and [1971]

Company and Location	Mill Capacity	Grade of Ore Milled (principal metals) Lead	Zinc	Copper	Silver	Ore Produced	Lead in Concentrates and Direct Shipping Ores	Remarks
	(tons ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
Newfoundland								
American Smelting and Refining Company (Buchans Unit), Buchans	1,250 [1,250]	7.18 [6.90]	12.89 [12.39]	1.13 [1.08]	3.73 [3.71]	291,000 [173,000]	19,791 [11,253]	Company reports 6 to 7 years' ore reserves remaining.
Nova Scotia								
Dresser Minerals Division of Dresser Industries, Inc., Walton	– [140]	– [3.30]	– [0.50]	– [0.36]	– [4.35]	– [16,125]	– [514]	Company announced permanent closure of operations.
New Brunswick								
Brunswick Mining and Smelting Corporation Limited,								
No. 12 mine, Bathurst	6,350 [6,000]	3.62 [3.25]	9.10 [8.11]	0.27 [0.30]	2.82 [2.44]	1,513,949 [1,567,000]	40,288 [38,844]	Mill refitted to treat 2,000 tpd of ore from No. 6 mine.
No. 6 mine, Bathurst	3,500 [3,500]	2.04 [2.11]	5.46 [5.76]	0.37 [0.36]	2.10 [1.86]	1,743,610 [847,000]	26,643 [19,860]	One third of ore treated in No. 12 mill. No. 6 mill now produces Zn and Pb concentrates in place of bulk concentrate.
Heath Steele Mines Limited, Newcastle	3,000 [3,000]	1.46 [2.23]	3.93 [5.29]	1.13 [0.97]	1.70 [2.21]	835,867 [972,456]	7,739 [10,322]	Mine on strike from July 1 to August 29, 1972. Sinking of No. 5 shaft and construction for mill expansion to start in 1973.
Nigadoo River Mines Limited,[1] Bathurst	– [1,000]	– [2.53]	– [2.66]	– [0.27]	– [3.37]	– [322,956]	– [7,771]	Operations suspended January 4, 1972.

Table 5 (cont'd)

Company and Location	Mill Capacity	Grade of Ore Milled (principal metals) Lead	Zinc	Copper	Silver	Ore Produced	Lead in Concentrates and Direct Shipping Ores	Remarks
	(tons ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)		
Quebec								
Manitou Barvue Mines Limited, Golden Manitou mine, Val-d'Or	1,600 [1,600]	0.33 [1.42]	1.16 [1.96]	– [–]	4.68 [4.42]	60,234 [225,915]	134 [651]	Operations suspended October 1971 to July 1972 due to low metal prices. Plan to increase production in 1973. Custom-milled the Louvem ore.
Sullivan Mining Group Ltd. Cupra Division, Stratford Centre	1,500 [1,400]	0.60 [0.63]	3.97 [3.86]	2.24 [2.29]	0.99 [1.05]	117,339 [134,663]	632 [390]	Mill treats ore from D'Estrie and Weedon divisions on custom basis. Ore reserves at August 31, 1972 at Cupra and D'Estrie totalled 1,450,000 tons assaying 0.62% lead, 2.20% zinc, 2.99% copper and 1.05 oz silver a ton.
D'Estrie Mining Company Ltd., Stratford Centre	custom-treated	0.72 [0.57]	3.28 [2.52]	2.70 [2.11]	1.21 [0.97]	109,138 [83,506]	706 [225]	
Ontario								
Big Nama Creek Mines Limited, Manitouwadge	custom-milled	– [0.06]	– [5.12]	– [0.81]	– [1.07]	– [41,717]	– [. .]	Operations suspended September 1971 because ore reserves depleted.
Ecstall Mining Limited, Kidd Creek mine, Timmins	10,000 [10,000]	0.39 [0.35]	10.14 [9.74]	1.44 [1.38]	4.35 [4.05]	3,628,501 [3,673,350]	8,663 [8,761]	Preproduction development work substantially completed on 800 and 1,200 ft levels. Mine expected to supply 2,000 tpd to concentrator by end of 1973.
Mattabi Mines Limited, Sturgeon Lake	3,000 [–]	1.27 [–]	11.97 [–]	1.27 [–]	4.99 [–]	438,838 [–]	987 [–]	Started production in August 1972.

Table 5 (cont'd)

	Mill Capacity	Grade of Ore Milled (principal metals) Lead	Zinc	Copper	Silver	Ore Produced	Lead in Concentrates and Direct Shipping Ores	Remarks
	(tons) ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
Ontario (cont'd)								
Noranda Mines Limited, Geco Division, Manitouwadge	5,200 [5,000]	0.15 [0.15]	4.30 [5.52]	2.12 [2.27]	1.93 [2.03]	1,815,164 [1,759,952]	2,095 [1,389]	Facilities installed to recycle tailings-pond decant water as mill process water supply.
Willroy Mines Limited, Willroy and Willecho mines, Manitouwadge	1,700 [1,600]	0.14 [0.13]	3.27 [3.33]	1.10 [0.89]	1.41 [1.36]	431,067 [427,589]	320 [317]	Extensive exploration program scheduled for 1973.
Manitoba–Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon	6,800 Central mill at Flin Flon treats the ore from all the company's mines						205[1] [206][1]	Only Chisel Lake and Ghost Lake mines have appreciable lead content.
Chisel Lake mine, Snow Lake, Man.		0.30 [0.30]	9.30 [8.40]	0.90 [1.00]	0.90 [0.90]	209,100 [163,200]		Production reduced when Ghost Lake mine started production.
Ghost Lake mine, Snow Lake, Man.		0.30 [–]	9.40 [–]	1.80 [–]	1.20 [–]	35,800 [–]		Production started in August 1972.
British Columbia								
Bradina Joint Venture	600	0.89	4.45	0.42	5.31	111,024	611	Mill commenced
Houston	[–]	[–]	[–]	[–]	[–]	[–]	[–]	operating in March 1972. Company considers entire year as part of preproduction period because of start-up problems in mine and mill.
Cominco Ltd., Sullivan mine, Kimberley	10,000 combined 10.8% Pb,Zn [10,000 combined 11.3% Pb,Zn]			– –	. . . .	1,925,099 [2,005,301]	93,253 [113,414]	In late 1972 company reopened H.B. mine which started production early in 1973.

Table 5 (cont'd)

		Grade of Ore Milled (principal metals)				Lead in Concentrates and		
	Mill Capacity	Lead	Zinc	Copper	Silver	Ore Produced	Direct Shipping Ores	Remarks
	(tons ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
Bluebell mine, Riondell	750 [750]	. . [. .]	. . [. .]	– –	. . [. .]	– [256,797]	– [10,505]	Operations suspended in December 1971 because ore reserves depleted.
Copperline Mines Ltd., Ruth-Vermont mine, Golden	600 [600]	. . [. .]	. . [. .]	– [–]	. . [. .]	– [58,593]	– [. .]	Operations suspended in June 1971.
Kam-Kotia Mines Limited, Silmonac mine, Slocan district	150 [150]	5.81 [6.39]	6.62 [6.60]	– [–]	16.44 [17.99]	27,429 [39,154]	1,503 [2,377]	Exploration and development work continuing.
Reeves MacDonald Mines Limited, Annex mine, Remac	1,000 [1,000]	0.59 [0.89]	7.07 [8.63]	– [–]	1.91 [2.51]	180,188 [166,089]	905 [1,334]	Developing ore zone under Pend-d'Oreille River.
Reeves mine, Remac		– [1.41]	– [4.50]	– [. .]	– [. .]	– [25,296]	– [275]	Operation suspended July 1971 because ore reserves depleted.
Teck Corporation Limited,[2] Beaverdell mine, Beaverdell	115 [115]	0.72 [0.70]	0.76 [0.80]	0.003 [–]	18.23 [17.52]	37,091 [36,404]	268 [256]	Exploration and development continue to locate new ore.
Western Mines Limited, Buttle Lake, Vancouver Island	1,100 [1,000]	0.68 [0.7]	6.02 [6.9]	1.85 [2.0]	. . [1.6]	374,022 [386,541]	2,545 [2,243]	New addition to concentrator. Price tunnel being driven through Myra Mountain to explore extension of ore zone.
Northwest Territories								
Pine Point Mines Limited, Pine Point	10,000 [10,000]	2.7 [2.6]	6.2 [6.5]	– [–]	. . [. .]	3,809,729 [3,891,927]	96,025 [95,849]	Company purchased property of Coronet Mines Ltd. Underground mechanical miner to be tested in 1973.

Table 5 (concl'd)

	Mill Capacity	Grade of Ore Milled (principal metals) Lead	Zinc	Copper	Silver	Ore Produced	Lead in Concentrates and Direct Shipping Ores	Remarks
	(tons ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
Yukon Territory								
Anvil Mining Corporation Limited, Faro	8,000 [7,700]	4.63 [4.92]	6.22 [6.74]	– [–]	. . [. .]	2,905,530 [2,673,000]	117,561 [113,352]	Mill capacity to be increased to 10,000 tpd; bulk Pb-Zn concentrate shipped to Germany.
United Keno Hill Mines Limited, Elsa, No Cash, Husky, Dixie mines, Mayo district	550 [550]	4.61 [5.17]	3.19 [5.19]	– [–]	34.23 [30.57]	80,646 [94,754]	3,516 [4.417]	Installed new hydraulic backfill plant for cut and fill stopes.

[1] Lead content of lead concentrates only. [2] Statistics for fiscal years ending September 30. – Nil; . . Not available.

electric industrial in-plant truck over the internal combustion engine variety has accelerated far beyond manufacturers' expectations. These electric trucks are now produced at the rate of half that of internal combustion units, compared with a fourth three years ago. Major battery manufacturers have been developing attractive battery-powered cars, buses and utility trucks and have been test driving them in normal driving cycles for the past two years in the United States. Marketing of these vehicles is now in progress and various companies and government agencies are using them. Recreational and household uses have also helped increase the demand for lead-acid storage batteries.

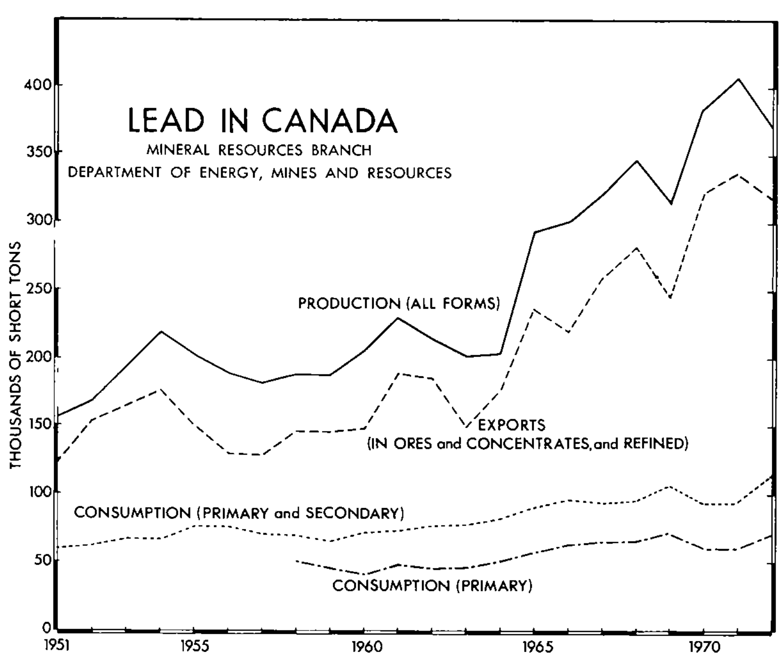
Lead's next most important use is as an antiknock additive in gasoline. Lead consumed for these two purposes in 1972 accounted for almost 65 per cent of total lead consumption in the United States. The metal is also used extensively for cable sheathing, collapsible tubes, caulking materials, corrosive-liquid containers and lead-base babbitts.

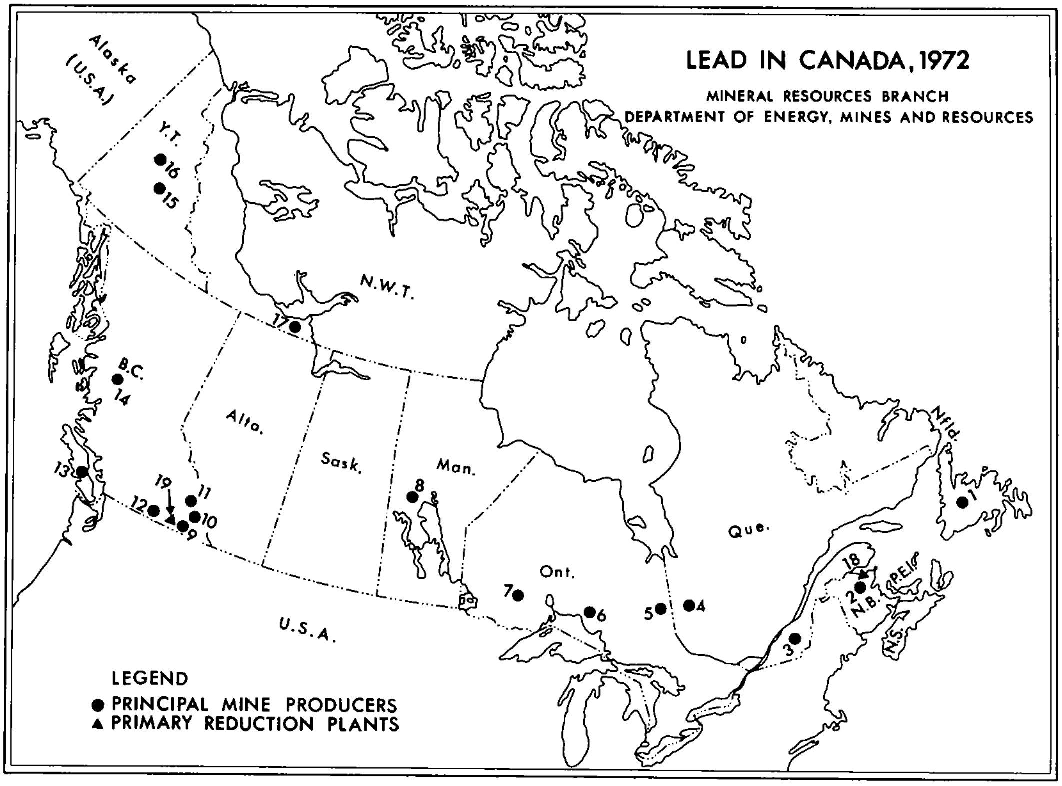
The commercial and residential construction industry is a growing market for lead in the form of soundproofing material, exterior roofing and decorative panels, waterproofing, flashing and construction panels. Because of its unique sound control characteristics there is an expanding use for lead in sound attenuation both as sheets and lead-composition panelling. Composite thermal-acoustical panels are now being used to contain the noise from industrial plants.

Table 6. United States consumption of lead by end-use, 1971-72

	1971	1972^p
	(tons)	
Storage batteries	679,803	649,197
Gasoline antiknock additives	264,240	278,340
Solder, type metal, terne metal and bearing metals	108,519	97,181
Ammunition and collapsible tubes	97,608	88,016
Pigments	81,258	89,331
Cable sheathing	52,920	47,763
Sheet and pipe	45,781	36,428
Caulking	29,993	19,785
Miscellaneous	71,392	58,673
Total reported[1]	1,431,514	1,364,714
Estimated undistributed consumption	–	64,000
Grand total	1,431,514	1,428,714

Source: United States Department of the Interior, Bureau of Mines Mineral Industry Surveys, Lead Industry in December 1972.
[1] Includes lead content of scrap used directly in fabricated products.
^{p} Preliminary; – Nil.





Principal mine producers

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
3. Sullivan Mining Group Ltd. Cupra Division
   D'Estrie Mining Company Ltd.
4. Manitou-Barvue Mines Limited
5. Ecstall Mining Limited
6. Noranda Mines Limited, Geco Division
   Willroy Mines Limited
7. Mattabi Mines Limited
8. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine)
9. Reeves MacDonald Mines Limited (Annex mine)
10. Cominco Ltd. (Sullivan mine)
11. Kam-Kotia Mines Limited (Silmonac mine)
12. Teck Corporation Limited (Beaverdell mine)
13. Western Mines Limited
14. Bradina Joint Venture
15. Anvil Mining Corporation Limited
16. United Keno Hill Mines Limited
17. Pine Point Mines Limited

Primary reduction plants

18. Brunswick Mining and Smelting Corporation Limited, Smelting Division
19. Cominco Ltd.

The possible loss of much of the important market for tetraethyl lead because of the requirements for atmospheric pollution control could be balanced by increased lead consumption to combat another major pollutant – noise. The International Lead Zinc Research Organization, Inc. has designed and begun construction of an all-metal house requiring a minimum of maintenance and containing approximately 1 1/2 tons of lead and zinc. Lead-coated steel sheeting that combines lead's corrosion resistance and sound-barrier properties with the strength of steel is now available for many building applications. In the allied field of vibration isolation, lead-asbestos antivibration pads are now being widely used in foundations for office buildings, hotels and apartments exposed to severe vibration from nearby heavy traffic. Because of its sound control qualities lead is also used in the mounting of various types of equipment including air-conditioning systems, heavy industrial equipment and commercial laundry machines.

The use of chrome yellow (lead chromate) paints on highways for pavement marking is growing because it is the most versatile low-cost pigment available for traffic control paints.

Miscellaneous uses include automotive wheel weights, ship ballast, terne steel and various alloys, and as lead-ferrite for permanent magnets in small electric motors. Relatively new uses are for leaded-porcelain enamel in coating aluminum and for radiation shielding against gamma rays in nuclear power reactors, nuclear-powered ships and submarines and shipping casks for transporting radioactive materials. Continuing research has developed new and promising markets for organometallic lead compounds in such applications as antifouling paints, wood and cotton preservatives, lubricant-oil additives, polyurethane foam catalysts, molluscicides, antibacterial agents and rodent repellents.

Refined lead is marketed in several grades that vary mainly according to the content of impurities, including silver, copper, arsenic, antimony, tin, zinc, iron and bismuth. The three principal grades are corroding, chemical and common desilverized lead. The corroding grade has the highest purity and is used chiefly in the manufacture of pigments, battery oxides and tetraethyl lead. Common lead is used mostly in industrial and home construction while chemical lead possesses superior creep and corrosion resistance and is ideally suited for cable sheathing.

Prices

The price of lead changed frequently during 1972. In Canada it was 13.5 cents a pound at the beginning of the year, and then rose in four steps to 16 cents on April 18 where it remained until October 18 when it dropped to 15 cents. This price prevailed until year-end. A somewhat similar pattern occurred in the United States. The price at the beginning of the year for common lead, fob New York, was 14 cents a pound. It rose to 14.5 cents on February 1 and to 15.5 cents on February 28. In July a two-tier pricing system came into effect and obtained for the rest of the year. It was 15.5-16.0 cents a pound from July until September 15 when it dropped to 15.0-16.0 cents. On October 12 it again declined to 14.5-16.0 cents which prevailed for the remainder of the year. The U.S. price of lead never reached the price ceiling of 16.5 cents established by President Nixon in August 1971 and, according to *Metals Week*, it usually sold at the lower end of the two-tier prices. On the London Metal Exchange (LME) lead opened the year at £93.50 (11.0 cents a pound Can.) and rose gradually to reach a high of £132.48 (13.9 cents Can.) on December 15.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
32900-1	Ores of metals, not otherwise provided for	free	free	free
33700-1	Lead, old, scrap, pig and block, per lb	free	free	1¢
33800-1	Lead, in bars and in sheets	5%	5%	25%

United States

Item No.		Noncommunist Countries	Designated Communist Countries
		(¢ per lb)	(¢ per lb)
		Effective December 20, 1971	
602.10	All lead-bearing ores, on lead content	0.75	1.5

Tariffs (concl'd)

	Unwrought lead		
624.02	Lead bullion, on 99.6% of lead content	1.0625	2.125
624.03	Other, on lead content		
624.04	Lead waste and scrap, on 99.6% of lead content		

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Lime

D. H. STONEHOUSE

Carbonate rocks, commonly known as limestones, can be classified according to their content of the minerals calcite ($CaCO_3$) and dolomite ($CaCO_3 \cdot MgCO_3$). They range from calcium limestone, containing less than 10 per cent magnesium carbonate to magnesian limestone, containing between 10 and 40 per cent magnesium carbonate and to dolomite, containing between 40 and 45.65 per cent magnesium carbonate. High-calcium limestones are those with less than 3 per cent total impurities. Limestones vary in colour, texture and hardness as well as in chemical composition, giving rise to a wide range of applications. Quicklime (CaO or CaO·MgO) is formed by the process of calcination, in which limestones are heated to the dissociation temperature of the carbonates (as low as 402°C for $MgCO_3$ and as high as 898°C for $CaCO_3$) and held at that temperature over sufficient time to release carbon dioxide. Although the word 'lime' is used generally, and wrongly, to refer to pulverized limestone as well as to forms of burned lime, strictly speaking it should refer only to calcined limestone (quicklime) and its secondary products, slaked lime and hydrated lime. The former is the product of mixing quicklime and water, the latter of slaked lime dried and possibly reground.

Calcination is accomplished in kilns of various types but essentially those of vertical or rotary design are used, having over the years incorporated many adaptations to the standard designs. Of comparatively recent design are the rotary hearth, travelling grate, fluo-solid and inclined vibratory types.

Canadian industry and developments

Lime plants have been established near urban and industrial centres in Canada where there are large reserves of suitable limestone and where most of the major consumers of lime are situated. Lime is a high-bulk, low-cost commodity and it is uncommon to ship it long distances when the raw material for its manufacture is available in so many localities. The more heavily populated and industrialized provinces of Ontario and Quebec together produced about 87 per cent of Canada's total lime output in 1972, with Ontario contributing two thirds of Canada's total. More limited markets in the other provinces resulted in much lower production in those areas. Commercial lime (lime that is normally produced for shipment and use off the plant site) was not produced in 1972 in Nova Scotia, Prince Edward Island, Newfoundland and Saskatchewan, the needs in each of these provinces being supplied from plants in neighbouring provinces or states.

During 1972, 17 companies operated a total of 22 lime plants in Canada: 1 in New Brunswick, 4 in Quebec, 9 in Ontario, 3 in Manitoba, 4 in Alberta and one in British Columbia. A total of 80 kilns was available – 21 rotary, 55 vertical, 1 vibratory-grate and 3 rotary-grate. Lime production in 1972 was 1,606,000 tons excluding some captive production such as that from pulp and paper plants that burn sludge to recover lime for reuse in the causticization operation, and that produced by a large iron and steel complex for its own use.

Atlantic provinces. In 1968 at Aguathuna, near Stephenville on the west coast of Newfoundland, Sea Mining Corporation Limited constructed a new plant designed to produce magnesium hydroxide from seawater. Although the plant was never operated commercially, a rotary kiln which was to produce lime for captive use in the extraction process was put into service during 1969 and 1970 to supply some quicklime for waste neutralization application on the island's east coast. This market is now supplied by Quebec-based lime producers.

Havelock Lime Works Ltd. began production of a high-calcium quicklime early in 1971, utilizing a newly installed, 100 tpd rotary kiln at the company's quarry site at Havelock, New Brunswick. Markets currently include mineral processing operations and pulp and paper industries mainly within the province as well as a growing export trade. The company's crushed limestone operation is scheduled for expansion during 1973-74. Snowflake Lime, Limited, which for many years produced lime at Saint John, has not rebuilt its lime-making facility following a fire in 1968. The quarries are still supplying crushed stone to the local construction industry.

Quebec. At Joliette, Domtar Chemicals Limited, Lime Division, produces quicklime and hydrated lime from a high-calcium Trenton limestone for the steel and pulp and paper industries. Shipments are made to Maritime consumers as well as to Quebec and Ontario.

Dominion Lime Ltd. produces high-calcium quicklime and hydrated lime from Silurian limestone

Table 1. Canada, lime production and trade, 1971-72

	1971		1972ᵖ	
	(short tons)	($)	(short tons)	($)
Production[1]				
By type				
Quicklime	1,340,935		1,368,000	
Hydrated lime	257,319		238,000	
Total	1,598,254	23,485,637	1,606,000	23,891,000
By province				
Ontario	1,167,053	16,885,560	1,095,000	15,846,000
Quebec	259,765	3,448,609	294,000	3,897,000
Alberta	100,483	1,985,380	120,000	2,374,000
Manitoba	. .	972,254	. .	1,016,000
British Columbia	–	–	. .	465,000
New Brunswick	. .	193,834	. .	293,000
Total	1,598,254	23,485,637	1,606,000	23,891,000
Imports				
Quick and hydrated				
United States	26,293	677,000	28,623	745,000
France	28	11,000	32	15,000
United Kingdom	124	4,000	24	1,000
Total	26,445	692,000	28,679	761,000
Exports				
Quick and hydrated				
United States	282,842	3,917,000	295,406	4,034,000
Guyana	500	9,000	408	9,000
Panama	19	1,000	210	5,000
Bermuda	362	9,000	94	2,000
Other countries	15	1,000	18	1,000
Total	283,738	3,937,000	296,136	4,051,000

Source: Statistics Canada.
[1] Producers' shipments and quantities used by producers. In 1971 distribution of shipments was as follows: shipped 1,135,000 st; used 463,000 st; total 1,598,000.
. . Not available; ᵖPreliminary.

at Lime Ridge, near Sherbrooke. Increased demand in Quebec is expected to absorb a major amount of additional production planned for 1973 when a new vertical kiln now under construction will increase output by 100 tons a day. Markets include steel, pulp and paper, construction and agricultural industries.

A high-calcium Ordovician limestone of the Beckmantown Formation has been mined for many years by Shawinigan Chemicals Division of Gulf Oil Canada Limited, near Bedford, for use in the company's carbide plant at Shawinigan. The quality of the limestone, containing less than 2 per cent silica and 0.015 per cent phosphorus, makes it a highly acceptable material for the production of calcium carbide. Hydrated lime made during calcium carbide-acetylene manufacture is sold for commercial use.

Ontario. Domtar Chemicals Limited, Lime Division, operates a limestone quarry and a lime plant at Beachville. The high-calcium limestone is mined, crushed, screened and used primarily as feed to the lime plant which has both vertical and rotary kilns. A new rotary kiln was put on stream in 1970, doubling plant capacity. At Hespeler, Domtar produces lime, crushed stone and agricultural limestone. The lime plant has vertical kilns and produces high-quality, white quicklime. Both plants also produce hydrated lime.

Table 2. Canada, lime, production, trade and apparent consumption, 1963-72

	Production[1]					
	Quick	Hydrated	Total	Imports	Exports	Apparent Consumption[2]
			(short tons)			
1963	1,204,824	245,907	1,450,731	44,291	98,084	1,396,938
1964	1,249,394	291,333	1,540,727	20,791	106,343	1,455,175
1965	1,340,386	280,018	1,620,404	25,334	239,334	1,406,404
1966	1,293,982	261,055	1,555,037	29,249	180,864	1,403,422
1967	1,178,109	244,790	1,422,899	22,113	90,125	1,354,887
1968	1,219,271	236,742	1,456,013	24,770	85,263	1,395,520
1969	1,388,109	246,753	1,634,862	41,226	195,160	1,480,928
1970	1,401,008	246,946	1,647,954	33,785	200,614	1,481,125
1971	1,340,935	257,319	1,598,254	26,445	283,738	1,340,961
1972[p]	1,368,000	238,000	1,606,000	28,679	296,136	1,338,543

Source: Statistics Canada.
[1] Producers' shipments and quantities used by producers. [2] Production plus imports less exports.
[p]Preliminary.

For many years Cyanamid of Canada Limited operated a quarry at Beachville to supply chemical-grade limestone to the company's lime plant at Niagara Falls where a battery of seven rotary kilns produced high-calcium lime for the manufacture of calcium carbide. In 1957 a rotary-kiln lime plant was built at Beachville and in 1967 a calcimatic kiln was installed; it was made operative during 1968. Decreasing demand for carbide has forced the company to phase out its Niagara lime operation. Limestone for use as open hearth and blast furnace flux, for portland cement manufacture and as a pulverized stone is also produced.

Through a subsidiary, Chemical Lime Limited, The Steel Company of Canada, Limited at Hamilton is supplied with flux stone and with high-calcium lime from a quarry and lime plant near Ingersoll. Vertical kilns were installed at the lime plant in 1959. A new rotary kiln of 325 tpd capacity was installed in 1971 to supply projected requirements of the company's steel manufacturing facilities at the Hilton Works.

Near Amherstburg, Allied Chemical Canada, Ltd. mines a high-calcium limestone for the production of lime which is used, along with salt from a nearby brine field, in the manufacture of soda ash. Canadian Gypsum Company, Limited produces a dolomitic lime near Guelph. Bonnechere Lime Limited, which operated kilns at Carleton Place and at Eganville for many years discontinued the manufacture of lime in mid-1970.

Early in 1969, Reiss Lime Company of Canada, Limited began construction of docking facilities on Lake Huron, just west of Spragge, to import limestone from the Rogers City area in Michigan for the manufacture of lime to be used in uranium processing. Production of high-calcium lime began in mid-1970 at an initial capacity of 65,000 tons a year. The company is owned by Denison Mines Limited and C. Reiss Coal Co., Wisconsin, U.S.A.

Western provinces. Effective March 1, 1972, the assets of the Production Division of The Winnipeg Supply and Fuel Company, Limited were acquired by Steel Brothers Canada Ltd. Included were the quarry and lime plant at Spearhill, the quarry at Falconer and the lime plant at Fort White. Winnipeg Supply staff was retained and production of lime and limestone has continued. The Spearhill operation produces a white, high-calcium lime, and limestone trucked to Fort White is processed using conventional equipment before introduction to a vibratory grate calciner. Quicklime is supplied to chemical, metallurgical and construction industries as well as to a growing market in the sewage treatment field. Limestone is supplied to The Manitoba Sugar Company, Limited.

Steel Brothers Canada Ltd. put a new rotary-kiln lime plant into operation early in 1968 at Kananaskis to replace the vertical, hanging kilns

Table 3. Canadian lime industry, 1972

Company	Plant Location	Type of Quicklime
New Brunswick		
1. Havelock Lime Works Ltd.	Havelock	High-calcium
Quebec		
2. Dominion Lime Ltd.	Lime Ridge	High-calcium[2]
3. Domtar Chemicals Limited	Joliette	High-calcium[2]
4. Gulf Oil Canada Limited Shawinigan Chemical Division	Shawinigan	High-calcium[2]
5. Quebec Sugar Refinery[1]	St-Hilaire	High-calcium
Ontario		
6. The Algoma Steel Corporation, Limited[1]	Sault Ste. Marie	High-calcium
7. Allied Chemical Canada, Ltd.[1]	Amherstburg	High-calcium
8. Canadian Gypsum Company, Limited	Guelph	Dolomitic[2]
9. Cyanamid of Canada Limited	Beachville	High-calcium
10. Chromasco Corporation Limited[1]	Haley	Dolomitic
11. Domtar Chemicals Limited	Beachville	High-calcium[2]
	Hespeler	Dolomitic[2]
12. Reiss Lime Company of Canada, Limited	Spragge	High-calcium
13. The Steel Company of Canada, Limited	Ingersoll	High-calcium
Manitoba		
14. The Manitoba Sugar Company, Limited[1]	Fort Garry	High-calcium
15. Steel Brothers Canada Ltd.	Spearhill	High-calcium
	Fort Whyte	High-calcium and dolomitic
Alberta		
16. Canadian Sugar Factories Limited[1]	Taber	High-calcium
	Picture Butte	High-calcium
17. Steel Brothers Canada Ltd.	Kananaskis	High-calcium[2]
18. Summit Lime Works Limited	Hazell	High-calcium
British Columbia		
19. Texada Lime Ltd.	Fort Langley	High-calcium

[1]Production for captive use. [2]Hydrated lime produced also.

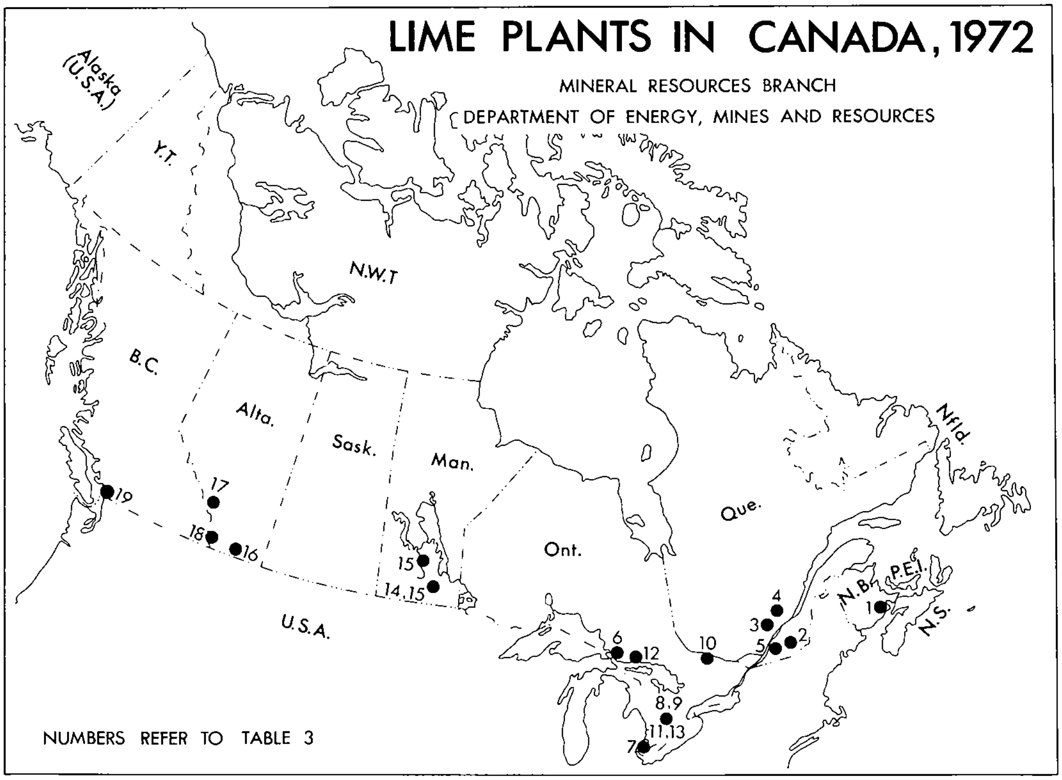
operated for many years. Limestone is quarried about 7 miles west of the plant site to provide kiln feed for the production of quicklime and hydrated lime. A second rotary kiln went on stream early in 1972, doubling the production capacity of the plant.

Summit Lime Works Limited, near Crowsnest, produces high-calcium limestone for use at sugar refineries, dolomitic and high-calcium stone for metallurgical use, high-calcium quicklime and hydrated lime for the chemical, metallurgical and construction industries.

During 1971 Texada Lime Ltd. constructed a calcimatic-kiln lime plant at Fort Langley, British Columbia capable of producing up to 200 tpd. Limestone is barged from Texada Island and the product – a high-calcium quicklime – is marketed throughout the mining and pulp and paper producing regions of British Columbia. The plant went on stream in February 1972. MacDonald Consultants Ltd. of Vancouver, in partnership with M C Q Industries of Columbus, Ohio, were responsible for the design and development of the project and will continue to supply management.

Markets, outlook and trade

The metallurgical industry provides the largest single market for lime. With the increased application of the basic oxygen furnace (BOF) in the steel industry, lime consumption increased greatly in certain areas of the United States and Canada. It is likely that the rate of



increase will level during the next year or so. The addition of hydrated lime in the pelletizing of iron ore concentrates has resulted in a stronger, more stable pellet and could develop as a substantial market for lime.

The pulp and paper industry is the second largest consumer of lime, most of which is used in the preparation of digesting liquor and in pulp bleaching.

The uranium industry uses lime to control hydrogen-ion concentration during uranium extraction, to recover sodium carbonate and to neutralize waste sludge. In the production of beet sugar, lime is used to precipitate impurities from the sucrate. It is used also in the manufacture of many materials such as calcium carbide, calcium cyanamide, calcium chloride, fertilizers, insecticides, fungicides, pigments, glue, acetylene, precipitated calcium carbonate, calcium hydroxide, calcium sulphate, magnesia and magnesium metal.

The rapidly growing concern for care and treatment of water supplies and the appeal for enforced antipollution measures should result in greater use of lime for water and sewage treatment. Research being done on the removal of sulphur from hydrocarbon fuels includes the formation of calcium sulphide on a fluidized bed of lime followed by the burning of sulphur-free gas. Lime is effective, inexpensive, can be regenerated and the emission of SO_2 to atmosphere is controlled.

Soil stabilization, especially for highways, offers a potential market for lime. However, not all soils have the physical and chemical characteristics which react properly with lime to provide a dry, impervious, cemented and stable roadbed. Hydrated lime added to asphalt hot mix prevents the asphalt from stripping from the aggregate. This could become more important as new technologies relating to asphalt maintenance and repair are adopted and as the sources of good clean aggregate become scarce.

Production of lime-silica bricks, blocks and slabs has not been as popular in Canada as in European countries. These lightweight, cellular, insulating masonry forms have many features attractive to the building construction industry.

Although quicklime and hydrated lime are not of relatively high monetary value, they are transported considerable distances in bulk or in packages if a market exists. Freight costs can represent a large part

Table 4. Canada, consumption of lime, quick and hydrated, 1970-71
(producers' shipments and quantities used by producers, by use)

	1970		1971p	
	(short tons)	($000)	(short tons)	($000)
Chemical and metallurgical				
Iron and steel plants	376,274	4,853	435,996	5,978
Pulp mills	110,690	1,607	163,479	2,555
Nonferrous smelters	87,002	1,329	75,039	1,032
Sugar refineries	28,929	669	(2)	(2)
Cyanide and flotation mills	71,268	1,022	49,017	674
Water and sewage treatment	28,116	454	62,468	1,026
Other industrial[1]	743,810	7,742	608,744	8,683
Construction				
Finishing lime	50,027	1,405	44,214	1,281
Mason's lime	17,174	329	30,293	685
Sand-lime brick	6,564	98	(3)	(3)
Agricultural	15,253	291	8,628	186
Road stabilization	7,604	85	9,082	162
Other uses	105,243	1,191	111,294	1,224
Total	1,647,954	21,075	1,598,254	23,486

Source: Statistics Canada.
[1] Includes uranium plants, glass works, fertilizer plants, tanneries and other miscellaneous industrial uses. [2] Confidential, included in "other industrial". [3] Confidential, included in "other uses".
p Preliminary

Table 5. World production of quicklime and hydrated lime, including dead-burned dolomite sold or used 1970-71

	1970	1971p
	(thousand short tons)	
U.S.S.R.	23,700	23,700
United States	19,747	19,591
West Germany	11,812	11,641
Japan	10,110	10,934
Italy	6,400	6,400
France	4,819	4,900
Poland	3,875	4,142
Belgium	3,187	3,311
East Germany	2,946	3,000
Czechoslovakia	2,368	2,485
Romania	2,217	2,300
Brazil	1,800	2,200
Canada	1,598	1,606
Other countries	11,807	11,886
Total	106,386	108,096

Source: U.S. Bureau of Mines *Minerals Yearbook* Preprint, 1971; and Statistics Canada.
p Preliminary.

of the consumer's cost. Limestones are well distributed in Canada but it does not necessarily follow that a lime-consuming industry will produce lime for captive use – lime producers will usually offer competitive prices. Nevertheless, some major users do produce lime for their own use and, especially in the United States in recent years, iron and steel producers have integrated backwards into lime manufacture.

Canada is a net exporter of lime.

Prices

Canadian lime prices quoted in *Canadian Chemical Processing* of August 1972:

Lime, carloads, fob works, bulk, per ton	
Ontario, quicklime	$16.50
Alberta, quicklime	20.50
Ontario, hydrated	17.00
Alberta, hydrated	21.00

Tariffs

Canada

Item No.		British Prefer-ential	Most Favoured Nation	General
29010-1	Lime	free	free	25%

United States

Item No.		On and after January 1 1971	1972
512.11	Lime, hydrated	0.5¢ per 100 lb incl. weight of container	free
512.14	Lime, other	0.5¢ per 100 lb	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated), 1972, TC Publication 452.

Lithium

G.H.K. PEARSE

Lithium, having a specific gravity of 0.534, is the lightest element that is solid at ordinary temperatures. It is a soft, ductile, silvery-white metal that oxidizes rapidly in air and reacts readily with water. Lithium finds a diversity of specialized uses as mineral, industrial compound and metal. The principal ore minerals are spodumene, petalite, lepidolite and amblygonite occurring in pegmatite bodies.

Lithium deposits have been mined in the United States since 1889 and in Europe and Africa since the early 1900's. Lithium was used solely in a pharmaceutical preparation until near the end of the 19th century when it became important as an ingredient in special glasses. The Edison cell storage battery using lithium hydroxide was invented in 1908 and shortly after World War I a hardened lead-base bearing alloy containing 0.04 per cent lithium was developed in Germany. Very little further research and development was done on lithium until World War II. During the war and continuing to the present, uses have multiplied dramatically and consumption has increased more than twentyfold in the last 25 years.

Canada's only significant producer of lithium, Quebec Lithium Division of Sullivan Mining Group Ltd., near Amos, Quebec, began production in 1955. Concentrates were shipped to United States under contract with Lithium Corporation of America until 1959 when the contract was cancelled. Production was then suspended, but was resumed on a reduced scale in 1960 to supply a new lithium chemicals plant. The mine was finally closed in 1965 in the face of a strike and reduced markets and prices.

Consumption of lithium products is increasing steadily under the stimulus of aggressive research and development by major producers in the United States. However, reserves of lithium in the United States, by far the world's principal consumer, are considerable and access to that market from outside is therefore restricted.

Occurrences, production and developments in Canada

There are five known areas in Canada where substantial reserves of lithium occur. The Val-d'Or - Amos area in northwestern Quebec in which the Quebec Lithium mine is located, has been the principal producer. Numerous spodumene-bearing pegmatites occur in northwestern Ontario, principally in the Nipigon district. Small amounts of amblygonite and lepidolite have been produced in the Winnipeg River district of southeastern Manitoba since its discovery in 1924. More recently, in this area, Tantalum Mining Corporation of Canada Limited, a wholly owned subsidiary of Chemalloy Minerals Limited, has delineated large reserves of spodumene ore at its Bernic Lake tantalum deposit. Several deposits have been explored in the Herb Lake area of northern Manitoba.

Amblygonite was recovered from two deposits in the Yellowknife-Beaulieu, Northwest Territories, district and small shipments were made between 1945 and 1955. Deposits in this district are currently considered too remote to be commercially viable.

Quebec. *Sullivan Mining Group Ltd., Quebec Lithium Division, Amos.* The Quebec Lithium property is underlain by numerous parallel pegmatite dykes trending easterly in a zone some 8,000 by 2,000 feet in the contact area between greenstones and granodiorite of the Lacorne batholith. Individual dykes are as much as 2,000 feet long and 100 feet wide. Total reserves have not been made known by the company but these are probably over 20 million tons grading 1.2 per cent Li_2O. Plant start-up was in 1955 with a throughput of 1,000 tons of ore per day by 1957. Upon cancellation of the contract with Lithium Corporation of America, production was temporarily suspended in 1959 and resumed at a reduced rate of about 250 tons per day in 1960 to supply the newly built lithium chemical plant. A strike curtailed production in October 1965 and in the face of dwindling markets and prices, management decided to close down operations and await more favourable developments in the industry. Stocks on hand were disposed of over the following two years. Total production from the mine was around 1 million tons of ore.

Other lithium properties of interest occur in the area.

Ontario. *Lithium deposits of the Nipigon district.* The first of numerous spodumene pegmatites southeast of Lake Nipigon was discovered in 1955. Exploration activity which followed outlined several deposits with significant tonnages and grades. The principal property in the area is that of Big Nama Creek Mines Limited, which is underlain by an *en echelon* dyke set totalling 2,800 feet in length and averaging 60 feet in width, and a parallel dyke to the south 800 by 60 feet. Diamond drilling to date has indicated 4.2 million tons

Table 1. Quebec lithium production, 1955-59

	Li_2O	
	(short tons)	($)
1955	57	63 thousand
1956	2,400	2.63 million
1957	2,550	2.94 million
1958	1,900	2.09 million
1959	1,250	1.37 million

grading 1.06 per cent Li_2O to a depth of 1,000 feet. Jean Lake Lithium Mines Limited and Ontario Lithium Company Limited have outlined 1.7 million tons grading 1.3 per cent and 2 million tons grading 1.09 per cent Li_2O, respectively. Other deposits of less than one million tons, which carry values up to 2 per cent lithia, occur in the district.

Development work done by Big Nama Creek Mines included the construction of a headframe, surface buildings, and the sinking of a shaft to 503 feet. Work was suspended in 1957.

Other occurrences. Other properties of interest have been explored in northwestern Ontario; one in particular near Lac La Croix, about 70 miles east-southeast of Fort Frances, has an indicated 1.5 million tons grading 1.20 per cent lithia over a strike length of 1,600 feet to a depth of 500 feet.

Manitoba. *Tantalum Mining Corporation of Canada Limited, Bernic Lake.* Numerous complex, zoned pegmatites bearing a variety of minerals are known in the Cat Lake - Winnipeg River district of southeastern Manitoba. Tantalum Mining Corporation's deposit at Bernic Lake has the double distinction of being the world's largest tantalum deposit and the only known commercial deposit of pollucite, the principal source of cesium. Diamond drilling from underground has recently outlined 5 million tons of spodumene ore in a newly located pegmatite sill underlying the present workings. The grade of the deposit is 3 per cent Li_2O over a width of 30 feet. This is possibly the richest orebody of its kind in the world. A few tons of lepidolite were shipped from the Bernic Lake property prior to the mid-1950's.

A loan from the Manitoba Development Corporation was secured by Tantalum Mining Corporation in February 1972, for the construction of a pilot mill to produce spodumene concentrates. This project is in the planning stages. If warranted, a spodumene unit could be incorporated in the mill circuit to process 350 to 450 tons of ore per day. The spodumene is low in iron and suitable for ceramics and glass.

Several other occurrences in the Cat Lake - Winnipeg River district contain over 1 million tons of reserves grading 1.2 per cent or more lithia. Petalite, amblygonite, and other less common lithium minerals occur particularly at the east end of Bernic Lake. Beryllium, tin, columbium, tantalum, rare earth and other elements occur in the pegmatites of this area.

Herb Lake district. The two principal occurrences in the Herb Lake district of northern Manitoba contain 2 to 3 million tons of spodumene ore grading 1.2 to 1.4 per cent Li_2O.

Northwest Territories. Many lithium-bearing pegmatites are known in the Yellowknife - Beaulieu district of the Northwest Territories. There are reserves of several tens of millions of tons in the district, principally of spodumene ore, but also including significant tonnages of amblygonite. The remote location and market conditions for lithium preclude exploitation of these deposits at present.

Other Canadian occurrences. Lithium pegmatites are known in several localities in the Appalachians and two occurrences are reported from the Revelstoke district in British Columbia. These are currently only of mineralogical interest.

Uses

The unique physical and chemical properties of lithium and its compounds have given rise to a diversity of uses which continue to increase. The metal is employed in metallurgical applications as an alloy constituent and as a scavenger and deoxidizer of other metals. Lithium is the most electro-positive of the elements, which with its light weight makes it attractive as an anode material in batteries. This application is actively being explored and within the last year several promising developments have been reported. The minerals lepidolite, petalite and spodumene find use as constituents in special glasses, ceramics, enamels, and as welding and brazing fluxes. Lithium chemicals are used in lubricating greases, as a catalyst in numerous organic chemical processes (rubber making, vitamins, etc.), as a dry chlorine vehicle for sanitation purposes, and in pharmaceutical preparations. The use of lithium carbonate in aluminum production cells increases recovery, reduces power requirements and reduces fluorine gas emission. Other lithium chemical applications include use in air conditioning, generation of oxygen and as an electrolyte in batteries.

World review

The United States is the world's principal producer and by far the greatest consumer of lithium products. Until World War II, world production was a little more than 100 tons of lithia (Li_2O) equivalent per year.* For 1972 world production is estimated to have topped 12,000 tons, two thirds of which was consumed by the United States.

* Production and consumption figures given are short tons of Li_2O equivalent except where otherwise indicated. These figures can be converted to lithium metal equivalent by dividing by 2.143.

Table 2. United States consumption of lithium[1], 1968 and 2000

	1968	2000 (ranges)
	(short tons Li_2O)	
Ceramics, glass	1,700	2,100 – 7,100
Grease	1,420	5,800 – 8,600
Humidity control	730	1,400 – 2,600
Welding, brazing	900	3,750 – 6,400
Alloying, etc.	620	2,000 – 4,100
Other	280	1,200 – 1,700
Total	5,650	16,250 –30,500

Source: Mineral Facts and Problems, 1970.
[1] Figures converted to Li_2O equivalent.

All three producers in the United States also manufacture lithium chemicals. Foote Mineral Company mines spodumene at Kings Mountain, North Carolina and recovers lithium carbonate from brines at Silver Peak, Nevada. Imported lithium minerals are also ground at the Kings Mountain Mill. American Potash and Chemical Corporation recovers lithium carbonate from brines at Searles Lake, California. Lithium Corporation of America, a subsidiary of Gulf Resources & Chemical Corporation, mines spodumene at Bessemer City, North Carolina and plans recovery from Great Salt Lake near Ogden, Utah.

The United States also imports lithium in the form of chemicals and minerals such as petalite and lepidolite for use in special glasses. Imports reached some 800 tons per year by 1967 and have since dropped to an estimated 130 tons in 1972. Exports of lithium products are about 800 tons a year.

Table 3. World lithium production, 1970-72

	1970	1971	1972
	(short tons Li_2O)		
United States	7,000^e	7,000^e	7,800^e
Argentina	22	17	21
Australia	54	49	64
Brazil	110	235	215
Mozambique	8	30	32
People's Rep. of China	650	650	700
Portugal	-	32	32
South-West Africa	490	490	500
Rhodesia	1,000^e	1,500^e	1,750^e
U.S.S.R.	1,500^e	1,500^e	1,750^e
Total	11,000	11,000	12,300

Sources: Various, including U.S. Bureau of Mines Commodity Data Summaries, January 1971, 1972 and 1973, and Mineral Resources Branch estimates.
^{e} Estimate.

Rhodesia was producing some 1,600 tons per year and was the primary supplier of United States import requirements until the UN embargo.

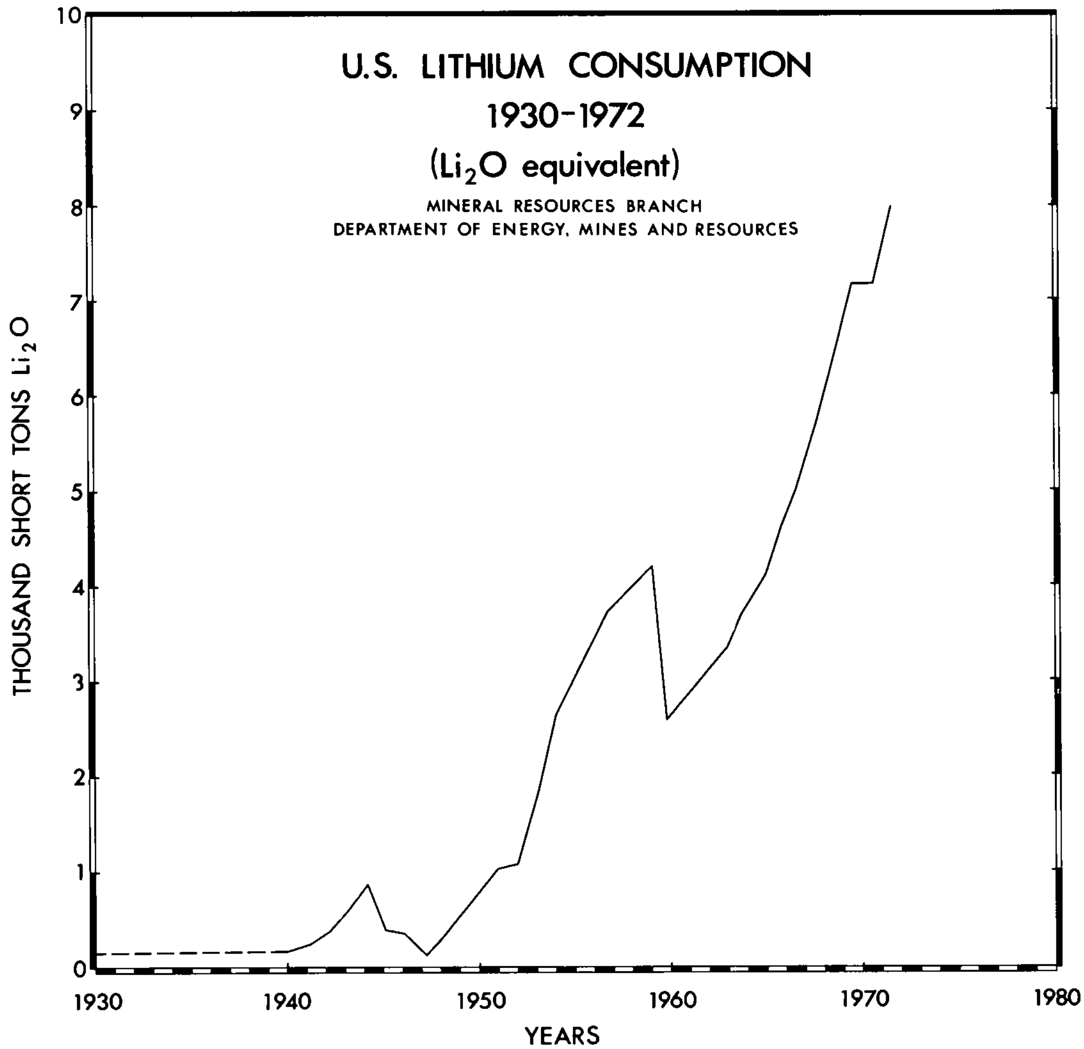
Other major producers include the U.S.S.R., the People's Republic of China, and South-West Africa.

World reserves of lithium were conservatively estimated by the United States Bureau of Mines in 1968 to be about 6 million tons of contained lithium (12.9 million tons Li_2O), 5.25 million tons of which occur in the United States. Canada's reserves were estimated to be about 200,000 tons. More recent figures and the addition of reserves known in Ontario, the Northwest Territories and other localities in Manitoba, which were not included, raise known reserves to over 400,000 tons of contained lithium (1 million tons Li_2O). Total world reserves are an order of magnitude more than adequate to meet anticipated requirements for the balance of the 20th century.

Outlook

The lithium industry is small in comparison with other segments of the mining and chemical industries. However, it has grown steadily since the end of World War II and continued growth at moderate rates is assured for the long term. Annual lithia consumption in the United States was estimated to be between 16,250 and 30,500 tons by the year 2000, based on projections made by the U.S. Bureau of Mines in 1968. It is noteworthy that 'other uses' were expected to expand from 280 tons in 1968 to as much as 1,700 tons by the year 2000.

Since the 1968 forecast, several breakthroughs in battery technology have been announced and the potential for such use as a power source for automobiles and for peak power generation has become evident. One estimate for peak power installation requirements is an initial 5,400 tons of lithia. Annual requirements for electric cars, assuming they prove feasible, could reach 30,000 tons by the turn of the century. World energy requirements will have to be met ultimately by thermonuclear reactors, the simplest form of which would utilize lithium, both as a heat transfer medium and a source of tritium for the reaction. The first practical plant is unlikely to be constructed until after the end of the century but research requirements in this area may well expand significantly before that. The surge in lithium consumption in the United States during the 1950's, which peaked in 1959, was probably due to procurements for thermonuclear research. Consumption figures for this purpose are kept secret but an estimate of over 7,000 tons between 1953 and 1959 can be made from the accompanying graph, which was constructed from numerous sources of qualitative and quantitative information. Fusion research uses may, therefore easily exceed 1,000 tons per annum during



Sources: Various, including U.S. Bureau Mines Publications, and Mineral Resources Branch estimates.

the 1990's. Given these developments, consumption in the United States could well exceed 50,000 tons per annum by 2000 or double the forecast high made in 1968.

Under these conditions Canada could once again become an important producer of lithium.

Magnesium

D.G. SCHELL

Magnesium is the third most abundant structural element in the earth's crust; it is even more plentiful than iron or aluminum. It is found in naturally occurring minerals such as dolomite, magnesite, brucite and olivine, also in seawater, brines and evaporite deposits. Magnesium is consumed mostly in the form of nonmetallic compounds, principally magnesium refractories. Metal represents only about 10 per cent of consumption on a magnesium content basis.

The metal is produced by two basic processes. One is by electrolysis of magnesium chloride derived from seawater and brines. The other is a silicothermic process whereby magnesium ore, such as dolomite or magnesite, is mixed with ferrosilicon and reduced at high temperatures. All Canadian production is by the latter method, which is more suitable for smaller plants. The electrolytic method has risen to prominence because of large-scale plants utilizing low-cost electric power. Electric power requirements to produce magnesium electrolytically are 8-9 kWh per pound, even higher than the 7-8 kWh required to produce a pound of aluminum by the conventional Hall-Heroult process, and considerably higher than for the silicothermic process, including production of the ferrosilicon.

Canada

The only Canadian producer of primary magnesium is Chromasco Corporation Limited. This company (formerly Dominion Magnesium Limited) has operated a mine and smelter at Haley, Ontario, 50 miles west of Ottawa, since 1942.

A high-quality (98% pure) dolomite, low in impurities such as silica and the alkali metals, is mined from an open pit and calcined in a rotary kiln to produce dolime. Using the Pidgeon process, dolime is mixed with ferrosilicon in a ratio of about 5 to 1. This mixture is charged in batches into retorts which are externally heated in furnaces, using natural gas as the main fuel. Under vacuum and at high temperature, the magnesium content is reduced and accumulates as crystalline rings known as 'crowns' in the water-cooled head sections of the retorts. The plant has an annual capacity of 12,000 tons* of magnesium metal, but operated at only about 50 per cent of capacity in 1972. A minor amount of this furnace capacity was used in the production of calcium.

The company produces ingots of magnesium metal in the following grades and purities: commercial 99.90 per cent; high-purity 99.95 per cent; and refined 99.98 per cent. Magnesium alloys are produced to all specifications. Other magnesium products include master alloys, rods, bars, wire and structural shapes. The Pidgeon process, described above, is particularly suited for production of the purer forms.

To produce commercial-grade magnesium, the crowns are simply remelted and cast into ingots. This grade is suitable for general fabrication purposes and for alloying with aluminum, and represents the major proportion of production. The high-purity grade is mostly used for the formation of Grignard reagents (alkyl-magnesium-halides which react to form a variety of organic and inorganic compounds). The refined grade is in demand for chemical laboratory use and as a reducing agent for titanium, zirconium, uranium and beryllium.

Production of magnesium in 1972, according to a preliminary report by Statistics Canada, was 5,844 tons, a decrease of 19 per cent from the previous year and well down from the 10,353-ton output of 1970. Although domestic consumption has increased since 1970, this positive factor has been more than counterbalanced by drastically curtailed exports and rising imports.

Domestic consumption of magnesium was 5,922 tons in 1972, a 6 per cent reduction from the 6,276 tons consumed in 1971 (see Table 2). One might note the apparently fluctuating Canadian consumption of this metal since 1969. This trend probably results from the relatively minor amount of magnesium consumed compared to many other metals and the fact that magnesium is highly vulnerable to substitution. Aluminum alloys are the predominant outlet for magnesium.

Imports of magnesium metal and alloys were 4,809 tons in 1972, a vast increase over the 1,979 tons imported in 1971 and much above the long-term trend for alloys and metal shown in Table 2. Low-priced imports from the United States and the U.S.S.R. have made serious inroads into the Canadian market at the expense of domestic production. Exports of Canadian magnesium in 1972 were 2,872 tons, slightly less than the 2,917 tons exported in 1971, and continuing the decline which began after the record exports of 1970. Exports of magnesium metal have entered the United States duty free under the Canada-United States

*All tons are short tons of 2,000 pounds unless otherwise specified.

Table 1. Canada, magnesium production and trade, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Production[1] (metal)	7,234	5,163,921	5,844	4,548,000
Imports				
Magnesium metal				
United States	1,827	1,458,000	3,247	2,446,000
U.S.S.R.	–	–	1,100	572,000
Other countries	–	–	110	72,000
Total	1,827	1,458,000	4,457	3,090,000
Magnesium alloys				
United States	119	267,000	209	283,000
Britain	33	81,000	142	292,000
Other countries	–	–	1	8,000
Total	152	348,000	352	583,000
Exports				
Magnesium metal				
United States	950	821,000	1,228	976,000
Britain	811	560,000	1,197	845,000
People's Republic of China	–	–	220	144,000
France	155	111,000	67	49,000
Hungary	173	120,000	47	33,000
India	122	100,000	36	26,000
Israel	35	38,000	16	26,000
Australia	–	–	16	25,000
Other countries	671	477,000	45	51,000
Total	2,917	2,227,000	2,872	2,175,000

Source: Statistics Canada.
[1] Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt.
^{p} Preliminary; – Nil.

Defense Production Sharing Program, but this program recently has operated on a reduced scale. Although the United States duty on magnesium ingots and further-processed products has been progressively reduced in accordance with the Kennedy Round of trade negotiations under the General Agreement on Tariffs and Trade, only in certain highly pure items can the Canadian product find a market in the United States except under the above-mentioned program. In the form of ingots, a 20 per cent United States tariff remains whereas the comparable Canadian tariff is 5 per cent.

World review

World production of primary magnesium in 1972 was 253,100 tons, as shown in Table 4, little changed from the previous year's output of 256,800 tons, although previous compilations of statistics indicate later information may increase this 1972 preliminary figure. The United States retained its dominant position, accounting for almost half of world production, followed by the U.S.S.R. and Norway. Secondary magnesium adds to the effective supply in some countries, notably the United States which produced an estimated 15,000 tons of secondary metal, Japan about 10,000 tons and West Germany about 5,000 tons, all based on 1971 statistics, the latest available.

A further source of magnesium metal is the General Services Administration stockpile in the United States. Sales from this government-owned stockpile in 1972 were 7,737 tons, much more than the 710 tons sold in 1971. Some 90,000 tons remained for disposal at the end of 1972. This stockpile metal must be reprocessed and cleaned, at a cost of 2 to 3 cents a pound, before it can be used in most applications.

During the 1960's there were frequent periods of magnesium shortage but supply and demand in 1972 were approximately in balance. By far the largest producer is The Dow Chemical Company in the United States; however, some new capacity is in prospect. The new plant of N L Industries, Inc. at

Table 2. Canada, magnesium production, trade and consumption, 1962-72

	Production,[1] Metal	Imports		Exports, Metal		Consumption,[2] Metal
		Alloys	Metal			
	(st)	(st)	(st)	(st)	($)	(st)
1962	8,816	..	..	..	3,967,932	3,614
1963	8,095	..	..	..	3,676,725	3,641
1964	9,353	187	1,594	..	3,951,386	3,762
1965	10,108	166	1,641	..	4,456,255	4,499
1966	6,723	330	3,011	..	3,452,000	5,137
1967	8,887	206	1,493	..	3,696,000	5,054
1968	9,929	302	2,403	..	4,261,000	5,654
1969	10,637	431	2,023	..	4,726,000	5,672
1970	10,353	256	2,036	7,669	5,562,000	4,937
1971	7,234	152	1,827	2,917	2,227,000	6,276
1972^p	5,844	352	4,457	2,872	2,175,000	5,922

Source: Statistics Canada.
[1]Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt. [2]Consumption, as reported by consumers.
^{p}Preliminary; .. Not available.

Table 3. Canada, consumption of magnesium 1962 and 1967-72

	1962	1967	1968	1969	1970	1971	1972^p
				(short tons)			
Castings[1]	252	631	601	793	850	1,316	1,109
Extrusions[2]	556	659	926	529	474	375	494
Aluminum alloys	2,175	3,253	3,713	3,710	3,123	3,972	3,924
Other uses[3]	631	511	414	640	490	613	395
Total	3,614	5,054	5,654	5,672	4,937	6,276	5,922

Source: Statistics Canada.
[1]Die, permanent mould and sand. [2]Structural shapes, tubing, forgings, sheet and plate. [3]Cathodic protection, reducing agents, deoxidizers, and other alloys.
^{p}Preliminary.

Rowley, Utah, began production of primary magnesium late in 1972, but at a rate much below its design capacity of 45,000 tons a year. Its shipments were insufficient to have a bearing on the market. American Magnesium Company's plant at Snyder, Texas, remained closed because of production problems which caused pollution of the environment. However, the company expects to resume production some time in 1973 and eventually attain its rated capacity of 30,000 tons a year. Aluminum Company of America (Alcoa) will construct a plant at Addy, Washington, to produce magnesium in 1975 by a ferrosilicon process. The plant will utilize the Magnotherm process patented by Pechiney Ugine Kuhlmann and will have an initial capacity of 24,000 tons of magnesium a year. Norsk Hydro is planning to expand its plant at Heroya, Norway, from 44,000 to 60,000 tons a year, but the timing has not been announced.

Statistics on world consumption of magnesium are incomplete and somewhat imprecise. However, consumption of magnesium in noncommunist countries in 1972 was estimated to be 210,000 tons, of which the United States used about 105,000 tons and Japan 19,000 tons. In 1971 France consumed an estimated

Table 4. World primary magnesium production

	1962	1971	1972[e]
	(thousand short tons)		
United States	68.9	123.5	120.8
U.S.S.R.	35.0	57.0	. .
Norway	16.4	40.2	40.0
Japan	2.3	10.7	11.0
Italy	6.3	8.8	9.0
Canada	8.8	7.2	5.8
Other noncommunist countries	7.2	8.3	9.5
Communist countries[1]	1.0	1.1	57.0
Total	145.9	256.8	253.1

Sources: For Canada, Statistics Canada. For other countries, 1962: U.S. Bureau of Mines, *Minerals Yearbook* 1963; 1971: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1971; 1972: U.S. Bureau of Mines, Commodity Data Summaries, January 1973.
[1]Production of U.S.S.R. Included in 1972, excluded in 1962 and 1971.
[e]Estimated; . . Not available.

6,500 tons and Great Britain 5,200 tons according to the most recent information. The consumption in West Germany, whose automotive industry is a large user, is unknown. This country absorbs most of Norway's sizable magnesium production.

Technology

Two technological developments are expected to have an impact on the growth of magnesium. The first is fluxless melting. To prevent molten magnesium from oxidizing, a salt flux cover may be utilized. Associated with fluxing are undesirable effects, such as hydrochloric acid fumes and metal losses due to entrapment in a sludge which sinks to the bottom of the melt. Fluxless melting utilizes a heavy inert gas, sulphur hexafluoride (SF_6) in place of flux. The process was pioneered by Volkswagen in West Germany and further development is being undertaken at the Battelle Memorial Institute in the United States.

The other development is the hot-chamber die-casting machine. Machines of this type were developed in West Germany and Italy and are operating on a commercial basis in Europe. Cost reductions through faster cycling, lower metal loss and thinner-walled castings are claimed for these new casting machines.

Uses

The major use of magnesium is in aluminum alloys where it provides hardness and strength. More magnesium is utilized in aluminum alloys than in magnesium alloys. Because of its high strength-to-weight ratio, magnesium is used in structural applications, i.e., those which involve load-carrying components. Although magnesium weighs only two thirds as much as aluminum, the latter metal can be substituted for magnesium in most structural applications, and a higher price has often placed magnesium at a disadvantage.

Typical structural uses of magnesium are in aircraft (particularly helicopters), missiles and space exploration vehicles, luggage frames, and materials-handling equipment such as gravity conveyors and hand trucks. Magnesium castings are used extensively in power lawnmowers, chain saws, typewriters and electronic equipment. The European automotive industry utilizes

Table 5. Estimated world primary magnesium capacity, 1972

	Company Name	Location	Annual Capacity
			(tons)
Canada	Chromasco Corporation Limited	Haley, Ontario	12,000(F)
France	Société Générale du Magnésium (Pechiney)	Marignac	9,900(F)
Italy	Society Italiana per il Magnesio e Leghe di Magnesio, Milan	Bolzano	7,700(F)
Japan	Furukawa Magnesium Company	Oyama	7,300(F)
	Ube Kosan KK	Ube	6,600(F)
Norway	Norsk Hydro-Elektrisk Kvaelsto-faktieselskab	Heroya, near Porsgrund	48,000(E)
United States	The Dow Chemical Company	Freeport, Texas	120,000(E)
	NL Industries, Inc.	Rowley, Utah	5,000(E)
U.S.S.R.	Various		57,000

Process: F-Ferrosilicon; E-Electrolytic.
Sources: Société française de minerais et métaux, and various others.

considerable quantities of magnesium, mainly in the form of engine blocks and other castings. However, the metal has been unable to gain a foothold in North American automobile manufacturing, its cost and somewhat questionable corrosion resistance being major disadvantages. Nevertheless, the increased weight of automobiles due to safety and pollution control devices should provide increased opportunities for utilization of the light metal, magnesium. New technical developments in fluxless melting and die casting should make magnesium more competitive.

Nonstructural applications, which have grown more quickly than structural uses, account for about 75 per cent of the consumption of magnesium. A rapidly growing sector of this market is for aluminum alloy beverage cans which contain about 2½ per cent magnesium. Other important nonstructural uses of magnesium are as an alloying element for ductile iron, as a reducing agent in the production of titanium for cathodic protection and in the chemical industry for Grignard reagents and as an antiknock fuel additive. One of the largest potential uses of magnesium, if it is accepted by the steel industry, is a magnesium desulphurization process. This would be a destructive use of magnesium in which no secondary material would be generated, and might result in sales to the steel industry as much as 40,000 tons a year.

Prices

The Canadian domestic quotation at the end of 1972 for standard alloys was 32.75 cents a pound, fob Haley, Ontario, a decrease of 2.25 cents during the year. However, the higher price prevailing earlier in the year probably involved some degree of discounting to a lower market price. United States magnesium prices, in U.S. currency, quoted in *Metals Week* of December 18, 1972 were as follows:

Magnesium metal, per lb, in 10,000-lb lots,
pig 99.8% 37.25¢
notched ingot 38¢

Magnesium die-casting alloy, AZ91B ingot, per lb 32.75¢

In December 1972 The Dow Chemical Company, the major world producer, announced a general increase of 1 cent a pound on magnesium metal and alloy prices, to be effective January 1, 1973.

Outlook

Over the short term, magnesium may come into short supply as world demand for metals increases. Magnesium prices are expected to rise moderately, following the trend of its main competitive material, aluminum. However, by the end of 1975, primary magnesium production capacity is anticipated to rise by 100,000 tons a year in the United States alone, if present plans materialize, with perhaps some smaller expansions in other noncommunist countries. A surplus may result unless the 8 per cent long-term growth trend of magnesium consumption increases. There is no expectation that this rate will change unless magnesium can penetrate some new markets. One of these possible new outlets is for desulphurization of steel. Another is the vast North American automotive industry, but magnesium must be more cost-competitive before achieving any significant progress in this field. A negative factor hindering its use, dependence on a single supplier in the United States, will be eliminated when the new United States producers attain their planned production rates.

The electrolytic magnesium industry, which depends on large quantities of low-cost electric power, may face future growth restrictions similar to the aluminum industry. Perhaps the new silicothermic plant to be built by Alcoa, with its lower electric power requirements, is the forerunner of a trend to ferrosilicon-type magnesium plants.

Tariffs

Canada

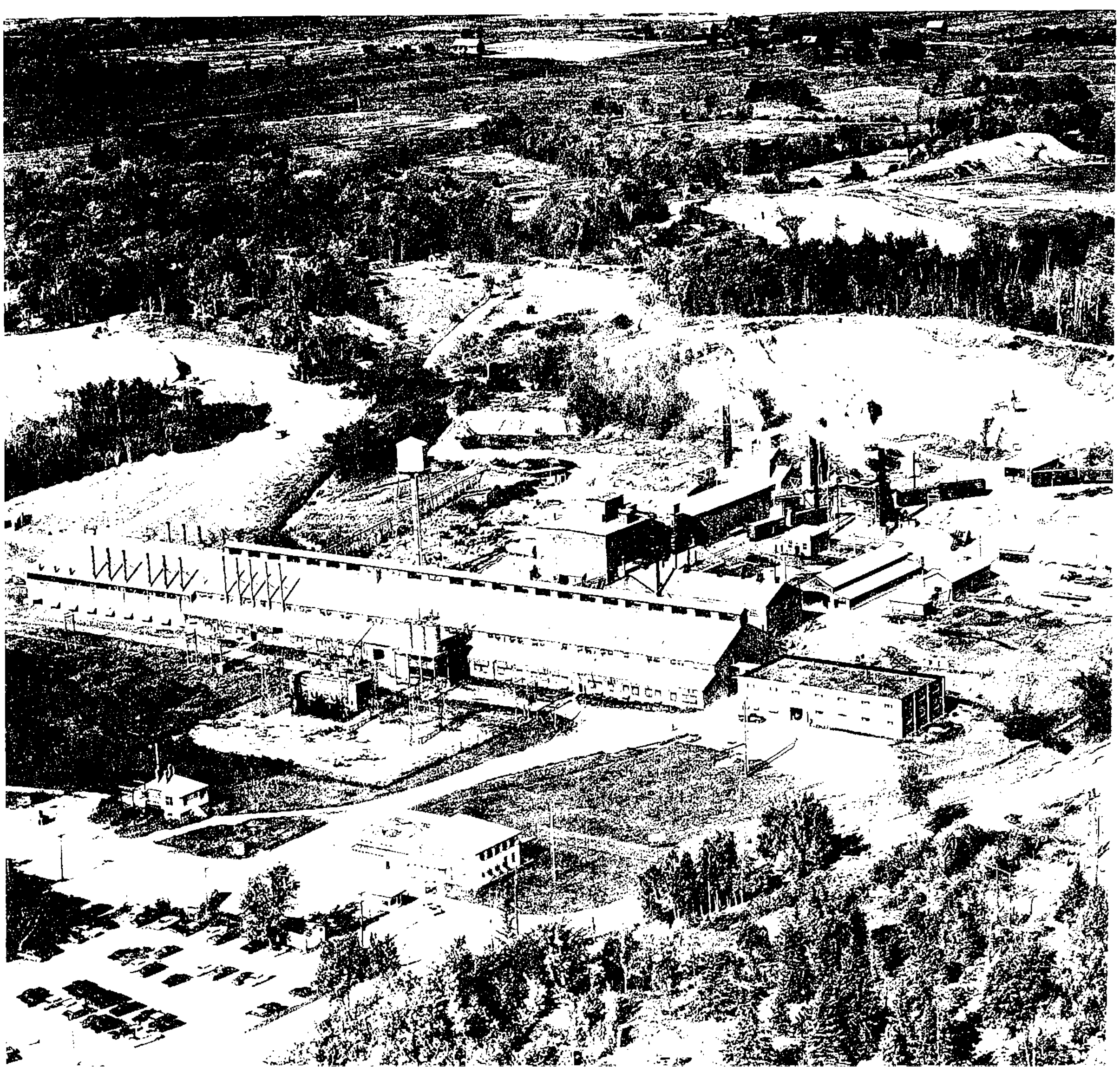
Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots, or blocks	5	5	25
34910-1	Alloys of magnesium, ingots, pigs, sheets, plates, strips, bars, rods and tubes	5	5	25
34915-1	Magnesium scrap	free	free	free
34920-1	Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufactures (expires 31 October 1975)	free	free	25
34925-1	Extruded tubing, of magnesium or alloys of magnesium, having an outside diameter of 5 inches or more, for use in Canadian manufactures (expires 28 February 1975)	free	free	25

Tariffs (concl'd)

United States	On and After January 1	
	1971	1972
628.55 Magnesium, unwrought, other than alloys; and waste and scrap (duty on waste and scrap suspended to June 30, 1973)	24%	20%
628.57 Magnesium, unwrought alloys, per lb on Mg content	9.5¢+4.5%	8¢+4%
628.59 Magnesium metal, wrought, per lb on Mg content	8¢+4%	6.5¢+3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

Chromasco Corporation Limited's magnesium smelter at Haley, Ontario. (George Hunter photo).



Manganese

D.D. BROWN

World production of manganese (Mn) ores during 1972 was an estimated 23 million short tons. High-quality manganese ores from many sources continued to be in abundant supply on world markets. Recent expanded production in Brazil, Gabon, South Africa and Australia has resulted in a highly competitive market and during 1972 expansion of world production capacity continued. Published United States manganese ore prices were unchanged in 1972 from the previous year with prices at a low level following a considerable decline during the 1960's. Since about 95 per cent of world manganese consumption is used in the steel industry, the rate of demand growth closely reflects the growth in world steel production. Average annual manganese consumption growth rate has been about 4.9 per cent a year in the noncommunist world since 1950.

Canada does not produce manganese ore, as known deposits contain either insufficient tonnages or less than ore-quality grades to be considered economically important. Canada imported 98,177 short tons of manganese (Mn content) in ores and concentrates valued at $5,074,000 in 1972 compared with 110,885 tons valued at $5,973,000 the previous year. Imports of ferromanganese were 18,985 tons valued at $3,238,000 and imports of silicomanganese were 16,637 tons valued at $2,960,000. Imports were 21,558 tons ($2,971,000) and 1,790 tons ($307,000), respectively, in 1971.

Continued abundant supply of high-quality ores from substantial world reserves can be expected, providing free competition continues among several large producing nations. Prices will probably remain at about present levels relative to current dollars for several years. Demand for manganese ores is relatively inelastic and barring major technological changes demand is expected to continue at an average growth rate of about 4 per cent annually through the remainder of the 1970's. If mining and processing of deep-ocean manganese nodules becomes operational in the long term increased supply pressure would adversely affect producers. However, the international legal regime under which ocean mining would operate is uncertain. World land-based reserves of metallurgical-grade manganese ores from a number of sources are sufficient for projected world demand for several decades.

Minerals and types of ore

Manganese occurs in many minerals that are widely distributed in the earth's crust but very few are of economic importance. The most common sources of the element are the minerals pyrolusite (MnO_2) and psilomelane ($MnO_2H_2O{\cdot}K,Na,Ba$ variable).

Metallurgical-grade manganese ore. Manganese ores having a manganese-iron ratio of 7 to 1 or more are preferred for making ferromanganese because it is possible to maintain a high productive capacity in the ferroalloy plant. High silica is undesirable because it increases the quantity of slag with attendant high loss of manganese. Since ores seldom have an ideal composition most ferromanganese producers use ores from more than one source and blend them to attain the specifications they require. Manganese ores imported by the United States in 1971 and used in producing ferromanganese, silicomanganese and manganese metal varied in grade from 35 per cent to 52 per cent manganese and averaged 49 per cent. General specifications for metallurgical-grade ore and the bases for price quotations call for 46 to 48 per cent manganese and maxima of 7 per cent iron, 8 per cent silica, 0.15 per cent phosphorus, 6 per cent alumina, and 1 per cent zinc. The ore should be in hard lumps of less than 4 inches and not more than 12 per cent should pass a 20 mesh screen.

Battery-grade manganese ore. Battery-grade manganese ores are subject to chemical and physical specifications but the principal requirement is a high manganese dioxide (MnO_2) content. Ores that are suitable for the manufacture of dry-cell batteries are usually suitable for metallurgical use but metallurgical ores are less frequently suitable for battery manufacture. Tests are carried out by making batteries from trial lots of ore and placing the batteries in test service. The composition of a battery-grade ore should generally be within the following limits:

	(per cent)
MnO_2	75-85
Total Mn	48-58
Absorbed moisture	3-5
Iron as Fe	0.2-3.0
Silicon as SiO_2	0.5-5.0
Other metallic impurities	0.1-0.2

Chemical-grade manganese ore. Manufacturers of manganese chemicals use ores of various grades including high-grade ores and concentrates also suitable for metallurgical use. They are used to make manganese chemicals such as hydroquinone, potassium permanganate, sulphates, and chlorides for use in the welding rod, glass, dye, paint and varnish, fertilizer, pharmaceutical and photographic industries.

Manganese ores of various grades are used in the manufacture of electrolytic manganese metal and in the production of synthetic manganese dioxide for the metallurgical, chemical and battery industries.

Table 1. Canada, manganese trade and consumption, 1971-72

	1971		1972p	
	(short tons)	($)	(short tons)	($)
Imports				
Manganese in ores and concentrates[1]				
Gabon	18,691	909,000	30,222	1,450,000
Brazil	54,000	2,469,000	33,173	1,411,000
United States	6,774	938,000	6,591	923,000
Republic of Zaïre	15,416	730,000	14,461	725,000
Ghana	9,903	603,000	10,290	391,000
U.S.S.R.	5,951	301,000	3,322	165,000
Mexico	118	5,000	113	8,000
Other countries	32	18,000	5	1,000
Total	110,885	5,973,000	98,177	5,074,000
Ferromanganese, including spiegeleisen[2]				
South Africa	19,872	2,500,000	12,217	1,702,000
United States	1,548	407,000	3,444	1,010,000
France	29	13,000	2,913	468,000
South Korea	–	–	255	37,000
Japan	34	13,000	47	11,000
West Germany	75	38,000	19	10,000
Total	21,558	2,971,000	18,895	3,238,000
Silicomanganese, including silico spiegeleisen[2]				
United States	124	37,000	8,431	1,666,000
Norway	1,106	198,000	6,943	1,079,000
South Korea	–	–	907	152,000
Yugoslavia	–	–	356	63,000
South Africa	560	72,000	–	–
Total	1,790	307,000	16,637	2,960,000
Exports				
Ferromanganese				
United States	10	1,000	2,122	60,000
Jamaica	146	29,000	156	28,000
Venezuela	225	59,000	–	–
Total	381	89,000	2,278	88,000
Consumption[2]				
Manganese ore				
Metallurgical-grade				
Battery- and chemical-grade				
Total	174,761	. .	183,175	. .

Source: Statistics Canada.
[1] Mn content; [2] Gross weight.
p Preliminary; – Nil; . . Not available.

Table 2. Canada, manganese imports, exports and consumption, 1962-72

	Imports			Exports	Consumption	
	Manganese Ore[1]	Ferromanganese Under 1% Silicon	Ferromanganese Over 1% Silicon	Ferro-manganese	Ore	Ferro-manganese
	(gross weight, short tons)					
1962	90,725	14,986	2,726	136	85,410	52,284
1963	106,891	22,639	2,355	10	92,270	58,555
1964	62,813	21,830	1,744	3,359	138,959	66,203
1965	89,480	34,562	787	3,817	119,289	61,352
1966	184,103	49,118	1,931	5,722	152,536	68,360
1967	82,659	16,044	4,202	4,339	137,395	61,667
1968	69,209	27,941	1,344	1,018	124,904	71,470
1969	107,954	24,524	4,599	5,512	168,485	70,305
1970	126,823	19,721	1,075	562	169,586	82,356
1971	110,885	21,558	1,790	381	174,761	76,420
1972^p	98,177	18,895	16,637	2,278	183,175	..

Source: Statistics Canada.
[1] From 1964, Mn content, prior years gross weight.
^{p} Preliminary; .. Not available.

Table 3. World production of manganese ores

	Mn^e	1970	1971^p	1972^e
	(per cent)	(thousands of short tons)		
U.S.S.R.	..	7,541	7,700^e	8,000
South Africa	30-40	2,954	3,568	3,600
Brazil	38-50	2,071	2,869	2,875
India	..	1,820	1,961	1,900
Gabon	50-53	1,601	2,060	2,250
China^e	30+	1,100	1,100	1,100
Australia	46	828	1,186	1,000
Ghana	48+	447	659	600
Republic of Zaïre	42+	382	427	420
Japan	30-43	298	314	300
Mexico	35+	302	294	300
Morocco	35-53	124	112	100
Other countries[1]		616	542	600
Total		20,084	22,792	23,045

Sources: United States Bureau of Mines, *Minerals Yearbook 1971;* 1972 author's estimate.
[1] Includes some 28 countries, each producing less than 40,000 tons a year.
^{e} Estimate; ^{p} Preliminary; .. Not available.

Canada

Most manganese ores imported into Canada are of metallurgical grade and are processed into manganese ferroalloys for use in the iron and steel industry. Union Carbide Canada Limited, Metals and Carbon Division, uses metallurgical-grade ore to manufacture standard high-carbon ferromanganese and silicomanganese at its plant in Welland, Ontario. Chromium Mining & Smelting Corporation, Limited produces manganese alloys, including high-carbon ferromanganese and silicomanganese, at its plant at Beauharnois, Quebec.

Union Carbide carried out a major expansion program at its ferroalloy plant at Beauharnois to bring into operation in 1973 a new 55,000-kva electric furnace having an annual production capacity of 80,000 tons of manganese alloys. To comply with Ontario air pollution abatement requirements and for economic reasons, Union Carbide in October phased out three of its seven electric furnaces used in the production of ferromanganese and silicomanganese at its ferroalloy plant at Welland, Ontario. The company conducts a continuing program to reduce emissions of particulate matter and other pollutants from its plants.

Foreign developments

The United States is the world's leading importer of manganese ores. The U.S. Bureau of Mines in its Mineral Industry Surveys reported imports of 1,620,246 short tons of manganese ore and consumption of 2,072,991 short tons, of which domestic ore represented 38,604 tons. Gabon and Brazil continued to be the two largest suppliers. United States imports of ferromanganese were 672,500 tons compared with 501,332 tons in 1971, with the Republic of South Africa and France again being the principal sources. United States exports of ferromanganese were 16,690 tons.

The United States government General Services Administration continued to offer surplus metallurgical-grade manganese ore for sale on a negotiated basis with deliveries limited to 300,000 short tons each fiscal year. The stockpile contained 7.9 million short tons of metallurgical ore on June 30, 1972, or 304 per cent of objective requirements. The stockpile also contained 271,000 short tons of battery-grade ore and synthetic dioxide, and 248,000 tons of chemical-grade ore.

Over 80 per cent of Japan's manganese demand is imported. Manganese imports during 1972 were 1.9 million short tons; ferromanganese imports were 220,000 short tons. Consumption of domestic ore was 261,000 short tons in 1972.

The U.S.S.R. has long been the world's leading producer of manganese ore, a position it will probably retain for many years. Estimated production in 1972 was 8.0 million tons. There are two manganese mining areas, each of which has large reserves – one is at Chiatura in the Georgian Republic and the other is in the Nikopol basin of the Ukrainian Republic. Manganese is recovered in both areas by open-cast and underground mining methods with most ore mined being beneficiated by gravity and in some cases by flotation methods. Russian manganese production plans envisage an increase from 7.5 million short tons in 1970 to 10 million tons by 1975 and 12 million tons by 1980. In the Nikopol basin preparations were under way during 1972 to add a new 1-million-ton-a-year open-pit mine and a beneficiation complex, which will produce more than 3.3 million short tons of manganese concentrates annually.

In the Republic of South Africa, the manganese industry is dominated by South African Manganese Ltd. and Associated Manganese Mines of South Africa Ltd., which operate several mines in the Postmasburg-Kuruman area of the northern interior of Cape Province. The companies produce a total of about 3.5 million short tons of manganese ore a year, or approximately 25 per cent of noncommunist world production. South African Manganese established a new underground mine at Wessels near Kuruman from which production began in November 1972. The combined capacity of mines operated by these companies is about 4.3 million tons a year.

In the Gabon Republic, Compagnie Minière de L'Ogooue (Comilog) completed an expansion program at its Moanda mine that increased annual production capacity to 2.46 million short tons.

In Ghana, gradual depletion of the N'suta Wassaw mine reserves will probably result in termination of manganese oxide ore mining operations by 1976.

In Australia, Groote Eylandt Mining Company, Pty. Ltd. (Gemco), a subsidiary of The Broken Hill Proprietary Company Limited, announced in 1972 that it would expand its production capacity to 1.38 million short tons of manganese ore a year. The output of the open-pit mine and concentrator on Groote Eylandt, in the Gulf of Carpentaria, was about

Table 4. Principal manganese additives

	Manganese	Silicon	Carbon
	(per cent)		
Ferromanganese			
High-carbon (standard)	74-82	1.25 max	7.53 max
Medium-carbon	74-85	1.50 max	1.50 max
Low-carbon	80-85	7.0 max	0.75 max
Silicomanganese	65-73	18-20 max	0.6-3.0
Spiegeleisen	16-28	1.00-4.50	.65
Electrolytic metal	99.87	0.025	0.004

Table 5. United States, consumption of manganese ferroalloys and metal, 1970-72

	1970	1971	1972
	(short tons, gross weight)		
Ferromanganese			
High-carbon	871,111	770,734	804,878
Medium- and low-carbon	129,500	128,277	141,362
Silicomanganese	138,500	122,913	120,836
Spiegeleisen	20,268	19,677	19,120
Manganese metal	24,482	27,523	30,205

Sources: United States Bureau of Mines: *Minerals Yearbook* for 1970; 1971 Preprint for 1971; Mineral Industry Surveys for 1972.

1 million tons in 1972. Gemco produces manganese pellets that contain 51-53 per cent manganese and premium fines of similar composition.

In Brazil, Industria e Comercio de Minérios S.A. (IOCOMI) at Santana, Amapa Territory, produced its first manganese pellets from ore fines in May 1972; plant capacity is 200,000 tons of pellets a year. Production was 2,569,000 short tons of washed metallurgical-grade ore in 1971.

Uses

The major use of manganese is in steel manufacture where it is used to remove sulphur, as a deoxidizer, and as an alloying constituent to improve the properties of strength, hardness and hardenability. The Hadfield or manganese steels, containing 10 to 14 per cent manganese, are noted for their ability to work-harden. The Brinell hardness of the metal is about 200 after heat treatment but steel-rail frogs have hardened in use to over 500 Brinell. Light blows of high velocity cause shallow deformation and hardening while heavy impacts produce deep hardening. Fine-grained manganese steels have unusual toughness and strength and are often used for making gears, spline shafts, axles, cylinders for compressed gas, crusher parts and many

Prices

United States prices in U.S. currency, published by Metals Week of December 20, 1971, and EMJ, December 1972

	December 20, 1971	December 1972
	(¢)	(¢)
Manganese ore, per long-ton unit (22.4 lb) CIF U.S. ports, Mn content		
Min. 48% Mn (low impurities)	(N) 63-68	(N) 63-68
Min. 46% Mn	(N) 61-63	(N) 61-63
Ferromanganese, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk per long ton of alloy		
	($)	($)
Standard 74-76% Mn	(N) 169.50	169.50
78% min. Mn	190.00	. .
low-phosphorus	(N) 220.00	. .
Imported standard 74-76% Mn, delivered Pittsburgh, Chicago	(N) 176-178	(N) 176-178
	(¢)	(¢)
Medium-carbon, per lb Mn	18.5-18.75	. .
"MS" manganese, per lb Mn	21.0	. .
Low-carbon, per lb Mn		
0.10% C	30.5	. .
0.30% C	29.5	. .
0.75% C	30.5	. .
Ferromanganese silicon, 0.05% C per lb alloy	16.8	. .
Ferromanganese briquettes, per lb alloy	9.2	. .
Manganese metal, electrolytic metal, 99.9%, per lb Mn, boxed, fob shipping point		
Regular	33.25	33.25
Hydrogen-removed	33.25	33.25
4-5%N	34.25	. .
6%N	36.25	. .
Silicomanganese, per lb of alloy, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk		
12½-16% Si, 3% C	10.65	. .
High-Mn, 15.5-17% Si		
1.75-2.25% C	11.90	. .
16-18½% Si, 2% C	10.65	. .
18-21% Si, 1½% C	11.38	11.38
Briquettes	11.00	. .

(N) Nominal; . . Not available.

other products. Manganese can substitute for part of the nickel content of stainless steel such as in the 200-series of stainless steels that contain 7 per cent manganese.

About 5 per cent of world manganese supply is consumed by nonmetallurgical industries, principally in the production of chemicals and dry cells. Manganese dioxide ores of various grade are used to make manganese chemicals such as hydroquinone, potassium permanganate, sulphates and chlorides. High-grade manganese ores from 75 to 85 per cent MnO_2 and definite chemical and physical properties are used in dry-cell battery manufacture.

Consumers

In Canada about 13 pounds of manganese are used in the form of ferromanganese and/or other manganese addition agents for every ton of crude steel produced. The principal Canadian consumers of ferromanganese are – in *Nova Scotia*: Sydney Steel Corporation, Sydney; in *Quebec*: Atlas Steels Division of Rio Algom Mines Limited, Tracey; Dosco Steel Limited, Montreal; in *Ontario*: The Algoma Steel Corporation, Limited, Sault Ste. Marie; Atlas Steels, Welland; Burlington Steel Division of Slater Steel Industries Limited, Hamilton; Dominion Foundries and Steel, Limited, Hamilton; The Steel Company of Canada, Limited, Hamilton.

Imported electrolytic manganese is used by Atlas Steels in the manufacture of low-carbon stainless steel. It is also used by the aluminum, magnesium and copper-alloy industries.

Consumers of battery-grade ore are National Carbon Limited and Mallory Battery Company of Canada Limited, both of Toronto, and Ray-O-Vac Division of ESB Canada Limited, Winnipeg.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
32900-1	Manganese ore	free	free	free
33504-1	Manganese oxide	free	free	free
35104-1	Electrolytic manganese metal	free	free	20%
			(¢)	(¢)
37501-1	Ferromanganese, spiegeleisen and other alloys of manganese and iron, not more than 1% Si, in the Mn content, per lb	free	0.5	1.25
37502-1	Silicomanganese, silico spiegel and other alloys of manganese and iron, more than 1% Si, on the Mn content, per lb	free	0.75	1.75

United States

Item No.		On and After January 1 1971	1972
		(¢ per lb on Mn content)	
601.27	Manganese ore (duty temporarily suspended to end of June 1973)	0.15	0.12
607.35	Ferromanganese, not containing over 1% C	0.3 + 2.5%	0.3 + 2%
607.36	Ferromanganese, containing over 1% but not over 4% C	0.55	0.46
607.37	Ferromanganese, containing over 4% C	0.35	0.3
632.32	Manganese metal, unwrought, waste and scrap (duty temporarily suspended on waste and scrap to end of June 1973)	1.5¢ per lb + 11% ad val	1.5¢ per lb + 10% ad val

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Mercury

J.G. GEORGE

The Pinchi Lake mine, some 30 miles north of Fort St. James, British Columbia, was the sole source of Canada's mine output of mercury in 1972. The Pinchi Lake mine, operated by Cominco Ltd., restarted operations in August 1968 with a mill with rated capacity of 800 short tons* of ore a day. In 1972 the mill processed only 203,000 tons of cinnabar ore compared with 248,000 tons in 1971. Production was restricted in 1972 to meet market requirements. Approximately 60 per cent of the ore was derived from underground operations with the remainder coming from an open pit which operated during the summer. Beneficiation of the ore consists in concentrating it by flotation, and then roasting the concentrate to produce a mercury vapour which in turn is cooled and condensed to produce liquid metallic mercury. In 1972 the roaster produced 14,600 flasks** of refined mercury. The Pinchi Lake mine's ore reserves at the end of 1972 were 1,800,000 tons containing 133,000 flasks of mercury compared with 2,000,000 tons of ore containing 141,000 flasks of mercury on December 31, 1971.

At its electronic materials plants at Trail, B.C., Cominco Ltd. also produces high-purity mercury metal with metallic impurities totalling ten parts per billion or less. This specialty metal product is manufactured mainly for special applications in the electronics industry, such as advanced radiation detector materials.

Very little exploration and development work was done in 1972 at Canadian mercury mining prospects because of the poorer demand and lower prices for mercury. Pursuant to an agreement made January 14, 1971 between Highland Mercury Mines Limited and Cominco Ltd., the latter did further exploration and development work on Highland's mercury property near Pinchi Lake, in the Omineca Mining Division of British Columbia. A small amount of development work was also done at a few mercury properties in the Bridge River district of southern British Columbia.

Canadian imports of mercury metal in 1972, at 174,700 pounds, were higher than the 122,000 pounds imported in 1971. Official statistics on Canadian production and exports of mercury are not available. Reported consumption in Canada in 1972 was 114,636 pounds, much lower than the 193,968 pounds consumed in 1971, because of the substantial reduction in the use of mercury in the production of heavy chemicals.

*All tons are short tons of 2,000 pounds unless otherwise specified. **The flask containing 76 net pounds avoirdupois is used throughout this review.

World review

Estimated world mine production of mercury in 1972 was 284,003 flasks or about 14,550 flasks lower than in 1971. Spain and Italy together accounted for about 36 per cent of the total output. The seven countries with the largest production, in declining order of output, were Spain, Russia, Italy, People's Republic of China, Mexico, Yugoslavia and Canada.

Mine output of mercury in the United States continued its decline in 1972 and, at 7,286 flasks, was the lowest since 1950. Production was derived from some 20 mines as against 55 mines in 1971 when 17,883 flasks were produced. By the end of 1972 there were less than six producing mines, most of which were operating on an intermittent basis. The closing of the Idria mine of New Idria Mining and Chemical Company in California in April brought to an end the once significant role of the United States as a mercury producer. The United States is believed to be the world's largest consumer of mercury but has always produced less than its requirements. Total consumption in 1972 in the United States of primary, redistilled and secondary mercury was estimated at 52,907 flasks, a slight increase over the 52,475 flasks consumed in 1971.

The insignificant change in the amount of mercury used in the United States was again attributed mainly to the problem of mercury pollution. The pollution factor became serious early in 1970, when fish caught in Lake St. Clair and Lake Erie were found to contain a high enough level of mercury to be declared unsafe for human consumption. It was eventually proven that the main source of the contamination was the mercury contained in effluents discharged into those waters from chlorine-caustic soda manufacturing plants located in the area concerned. Very little time was required to virtually eliminate any further contamination of these waters, but the problem of how to remove the mercury from the bottom of these and other lakes and rivers where it has been dumped for years remains unsolved. Some plants that have been

Table 1. Canadian mercury production, trade and consumption, 1971-72

	1971		1972p	
	(pounds)	($)	(pounds)	($)
Mine production	..	..	1,109,600	..
Imports (metal)				
Mexico	35,500	125,000	68,000	172,000
Spain	3,800	12,000	56,700	158,000
United States	81,700	342,000	22,800	75,000
Peru	–	–	14,600	44,000
Netherlands	–	–	7,600	18,000
Sweden	–	–	3,000	13,000
Britain	1,000	6,000	2,000	4,000
Total	122,000	485,000	174,700	484,000
Consumption (metal)				
Heavy chemicals	181,913		93,860	
Electrical apparatus	10,426		19,134	
Gold recovery	921		861	
Miscellaneous	708		781	
Total	193,968		114,636	

Source: Statistics Canada, except figure for mine production in 1972 was obtained from company annual reports.
pPreliminary; – Nil; .. Not available.

Table 2. Canadian mercury production, trade and consumption, 1963-72

	Production, Metal	Imports Metal	Imports Salts	Exports, Metal	Consumption, Metal
	(pounds)	(pounds)	($)	(pounds)	(pounds)
1963	–	447,592	9,521	..	147,396
1964	5,548	293,900	..	..	208,304
1965	1,520	1,071,900	..	..	415,996
1966	–	404,600	..	..	171,588
1967	–	356,300	..	..	245,121
1968	..	197,900	..	..	327,939
1969	..	133,600	..	..	308,814
1970	..	153,300	..	..	340.558
1971	..	122,000	..	..	193,968
1972p	1,109,600	174,700	..	..	114,636

Source: Statistics Canada, except figure for production in 1972 was obtained from company annual reports.
pPreliminary; – Nil; .. Not available.

using mercury cells to produce chlorine and caustic soda have recently converted to the diaphragm cell process which does not require mercury.

Because of lower prices which prevailed until about mid-1972 and the closing of the country's largest producer, Mercurios Mexicanos, S.A., Mexican production declined from 35,390 flasks in 1971 to an estimated 25,000 flasks in 1972. Beset by labour and financial difficulties, Mercurios Mexicanos reportedly declared bankruptcy and ceased operations about mid 1972. It had been producing at an annual rate of some 5,000 flasks. In Spain, the Minas de Almaden

Table 3. World mine production of mercury

	1968	1971	1972^p
		(flasks)	
Spain	56,943	50,831	60,500^e
U.S.S.R.^{e}	45,000	50,000	50,000
Italy	53,317	42,613	42,120^e
People's Republic of China^e	20,000	26,000	26,000
Mexico	17,202	35,390	25,000^e
Yugoslavia	14,794	16,593	16,419
Canada	. .	. .	14,600
Turkey	4,670	10,460	11,000^e
Algeria	. .	7,136	9,200^e
United States	28,874	17,883	7,286
Czechoslovakia	116	5,628	5,800^e
Japan	5,084	5,564	5,172
Philippines	3,544	5,020	4,900^e
Peru	3,132	3,390	3,400^e
Ireland	–	2,345	1,250
Other countries^e	7,018	19,699	1,356
Total	259,694	298,552	284,003

Sources: Preprint from the 1970 U.S. Bureau of Mines *Minerals Yearbook*, for 1968 figures. U.S. Bureau of Mines, Mineral Industry Surveys, Mercury in the First Quarter 1973, for 1971 and 1972.
^{p} Preliminary; ^{e} Estimated; – Nil; . . Not available.

Company, whose Almaden mine is the largest and richest mercury producer in the world, announced the development of a new process for treating waste residues from its roaster to yield an additional 5,000-10,000 flasks of mercury a year. The current stockpile of residues could reportedly provide an additional 200,000-300,000 flasks. Yugoslavia is reported to be interested in the new technique, as are Soviet metallurgists. Russia, which produced an estimated 50,000 flasks of mercury in 1972, became an important factor in the market during that year when it sold relatively large quantities of the metal in western Europe. The U.S.S.R. also disclosed plans to build a large mercury mining and metallurgical complex near Magadan on the Chukota Peninsula, in eastern Siberia. Construction plans were reportedly authorized after discovery of a deposit of mercury in commercial quantities. By late 1972 Chinese mercury was reported to be slowly moving into Western markets, including the United States.

World consumption of mercury is believed to have declined slightly in 1972, mainly as a result of the general public outcry against environmental pollution. In several large industrial nations, including the United States, the use of mercury in many of its applications was adversely affected by this unfavourable publicity. One of the metal's two major uses, as a cathode in the electrolytic preparation of chlorine and caustic soda, continued to be a principal target of the ecologists because of the danger of pollution from the effluents. The danger of mercury poisoning has also cut into other markets for mercury, such as in the agriculture and pulp and paper industries.

A weakness in the market, attributed to overproduction, excessive stocks and reduced demand, which developed in 1970, continued in 1971 and during most of the first half of 1972. As a result, prices again declined substantially with New York prices reaching a low of $145 a flask late in April 1972, the lowest in over twenty years. During the second half of 1972 the price trend was almost continually upward, partly as a result of improved consumer interest which in turn was largely attributed to the general revival in international business and trade. The closure of several mines, as well as the concerted action taken by many of the major producers to curtail production and withhold supplies from the marketplace, also helped to bring about the reversal in the price trend.

At the end of 1972, United States government stockpiles contained a total of 200,105 flasks of mercury; the stockpile objective remained unchanged at 126,500 flasks. There were no disposals from these stocks in 1972 and the surplus of 73,605 flasks requires Congressional approval before it can be released. Such stocks are, however, exclusive of excess mercury held by the United States Atomic Energy Commission (AEC). In June 1969, these surplus AEC stocks, which do not require Congressional authorization prior to being sold, were declared to be 15,000 flasks. Between then and the end of 1971, a total of 7,277 flasks of this excess AEC mercury was sold, leaving an unsold surplus of 7,723 flasks. Partly because of the depressed condition of the mercury market, General Services Administration (GSA) did not offer for sale during the first half of 1972 any of the surplus AEC stocks. But late in June 1972 GSA announced that monthly offerings of such stocks would be resumed in July of that year at the rate of 500 flasks (maximum) a month, with metal so sold being restricted to domestic consumption. This new rate is one third of the previous offering rate of 1,500 flasks per month (maximum) which was discontinued in August 1970 because of the unfavourable condition of the mercury market. During the second half of 1972 a total of 499 flasks was sold, and 13 flasks were released to other government agencies, leaving an unsold surplus of 7,211 flasks of AEC mercury at December 31, 1972.

Because of the hazards to health from mercury pollution, the U.S. Environmental Protection Agency (EPA) announced in March 1972 the suspension of federal registrations for all alkyl mercury pesticides and all other mercury products used for crop spraying, treatment of rice seeds, in laundry procedures and mixed in marine antifouling paints. The order halted immediately all interstate commerce in these products and, in effect, banned their further use. At the same time EPA issued cancellation notices to manufacturers of about 750 other mercury pesticides, including those used in mildew-proofing paints, the treatment of logs and lumber to prevent stain and mildew, the control of diseases affecting wheat and barley and the control of snow-mold on golf courses. The less severe 'cancellation' order allows manufacturers 30 days during which to file an appeal which can lead to public hearings or a scientific review of the government order. No such hearings were held in 1972. If an appeal is filed, sale and interstate commerce in the products concerned are permitted until a final decision is reached by a special scientific panel.

Outlook

Although the tide of adverse publicity from ecological and other sources now appears to be subsiding, pollution fears continued to weaken the demand for mercury and cause a decline in prices during the first half of 1972. The New York mercury price reached an all-time high of $775 a flask in June 1965 and from then until the end of 1968 it fluctuated considerably. From the beginning of 1969 through much of the first half of 1972 the trend was steadily downward. However, as a result of some mine closures, restrictions in output and market withdrawals, prices increased substantially during the latter part of 1972. Over the next few years, however, mercury prices are expected to fluctuate, mainly because of erratic demands. The fluctuations may not be as severe as in past years if the co-operation now existing between some of the world's leading producers, including those in Spain and Italy, leads to concerted action to stabilize prices.

Because of the continuing upturn in the United States economy and the anticipated improvement in the economies of Europe and Japan, the outlook for mercury for 1973 and some years thereafter is thought to be somewhat more favourable than it was a year ago. Much will depend, however, on the continued determination of the major producers to control offerings to the market and hence, prices. There is the risk that rising prices, if sustained for any period, might lead to the reopening of mines that cannot be operated economically under present conditions. Also overhanging the market is the substantial quantity of over 200,000 flasks in the United States government's stockpile. Another bearish factor is the possibility of

Table 4. United States mercury consumption, by uses, primary and secondary in origin

	1968	1971	1972ᵖ
		(flasks)	
Agriculture[1]	3,430	1,477	1,836
Amalgamation	267	*	*
Catalysts	1,914	1,141	800
Dental preparations	3,079	2,387	2,983
Electrical apparatus	19,630	16,938	15,553
Electrolytic preparation of chlorine and caustic soda	17,453	12,262	11,519
General laboratory use	1,989	1,809	594
Industrial and control instruments	7,978	4,871	6,541
Paint:			
antifouling	392	414	32
mildew-proofing	10,174	8,191	8,190
Paper and pulp manufacture	417	*	1
Pharmaceuticals	424	682	578
Other[2]	8,275	2,300	4,258
Total known uses	75,422	52,472	52,885
Total uses unknown	–	3	22
Grand total	75,422	52,475	52,907

Sources: Preprint from the 1971 U.S. Bureau of Mines *Minerals Yearbook*, for 1968 and 1971. U.S. Bureau of Mines, Mineral Industry Surveys, Mercury in the First Quarter 1973, for 1972.
[1] Includes fungicides and bactericides for industrial purposes. [2] Includes mercury used for installation and expansion of chlorine and caustic soda plants, and quantities in 1971 and 1972 for categories listed as not available for publication.
ᵖ Preliminary; – Nil; * Data not available for publication.

Table 5. Average monthly prices of mercury in 1972 at New York and cif main European port

	New York[1]	Cif Main European Port[2] Low	Cif Main European Port[2] High
		(U.S.$/flask)	
January	213.238	205.750	210.500
February	207.750	196.444	201.222
March	185.000	171.000	175.778
April	152.500	138.571	144.143
May	170.455	148.500	158.000
June	196.364	172.111	182.667
July	211.150	186.625	195.625
August	245.783	218.125	226.875
September	255.650	237.222	245.000
October	254.955	233.889	241.667
November	256.955	240.000	245.500
December	269.650	246.000	251.000

Sources: *Metals Week* for New York prices; *Metal Bulletin* (London) for cif main European port prices.
[1] Prime virgin metal. [2] Prices are cif main European port, min. 99.99%.

increased competition from Russia which has been disposing of mercury in western Europe, but not in the United States because of higher import duties obtaining there. The market could also be faced with increased offerings from Turkey resulting from new cinnabar discoveries and modernization of some of its existing mines.

Uses

One of the oldest but now relatively unimportant applications of mercury is for recovering gold and silver from their ores by amalgamation. The two major uses in recent years have been for electrical apparatus and for the electrolytic production of chlorine and caustic soda, although both uses have been declining. Together these two uses accounted for an estimated 55 per cent of mercury consumed in the United States in 1972. Electrical uses include mercury lamps, batteries, rectifier bulbs, oscillators, and various kinds of switches including 'silent' switches for use in the home. Because mercury lamps are adaptable to higher-voltage supply lines than those used with incandescent lamps, they are used as fluorescent lamps and for industrial and street lighting purposes. The mercury battery invented in 1944 is basically a dry-cell type battery. It has a relatively long shelf life and can withstand high temperature and high humidity. It is used in Geiger-Muller counters, portable radios and two-way communications equipment, digital computers, electronic measuring devices, hearing aids, guided missiles, and spacecraft.

Other applications are in mildew-proofing paints, industrial and control instruments, pharmaceuticals, insecticides, fungicides, bactericides, and dental preparations, although in some countries some of these uses have recently been restricted by government regulations. Several mercury compounds, especially the chloride, oxide and sulphate, are good catalysts for many chemical reactions, including those involved in the making of plastics. Because of its capacity to absorb neutrons the metal has been used as a shield against atomic radiation. One of the more recently developed applications for mercury is in frozen mercury patterns for manufacturing precision or investment castings. Mercury is superior to wax, wood or plastic pattern materials because of its smooth surface and uniform expansion upon heating. New technologies could open up new areas of use in the nuclear field, metal-chloride vapours, plastics, chemicals, amalgams and ion exchange.

Prices

The price of mercury per flask, fob New York, as quoted in *Metals Week*, fluctuated in 1972 between a low of $145 in April and a high of $285 in December. Average for the year was $218.28 a flask compared with an average of $292.41 for 1971. The cif main European port price, as quoted in *Metal Bulletin* (London), fluctuated between a low of $133 a flask in April and a high of $254 in December.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92805-2	Mercury metal	free	free	free
92828-4	Mercuric oxide for manufacture of dry-cell batteries (expires February 28, 1974)	free	free	25%

United States

Item No.		
601.30	Mercury ore	free
632.34	Mercury metal, unwrought, and waste and scrap	12.5¢ per lb, on and after January 1, 1972

Sources: For Canadian tariffs, The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States tariffs, Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Molybdenum

D.D. BROWN

In 1972 the supply of molybdenum continued to exceed demand. World* mine production of molybdenum was an estimated 148 million pounds compared with 150 million pounds in 1971. Estimated consumption was up 7 million pounds from a year earlier to 134 million pounds, bringing production more closely in balance with demand. The increase of 5 1/2 per cent in consumption was the result of increased production of specialty, stainless and tool steels. In response to the bleak supply-demand situation at the beginning of the year, production cutbacks and closures by primary molybdenum producers continued. At year-end, total noncommunist world producers' inventories amounted to at least 100 million pounds of molybdenum, equivalent to a nine-month supply. The excess supply resulted in price weakness through discounting.

An improvement in world demand resulted from increased steel production as 1972 progressed and a record level of steel production in 1973 appeared likely. The world iron and steel industry accounts for over 80 per cent of molybdenum consumption. The United States produced 72 per cent, followed by Canada with 15 per cent and Chile, 10 per cent.

In 1972 Canada's production (shipments) was 24,844,000 pounds of molybdenum valued at $34,022,000 compared with 22,662,732 pounds of molybdenum valued at $38,367,344 in 1971. Mine production, estimated from company reports, declined to 22.2 million tons from 30.4 million tons the previous year, principally as a result of the closing of the Alice Arm, B.C., operation of British Columbia Molybdenum Limited, and reduction of output by Canex Placer Limited (wholly owned subsidiary of Placer Development Limited) at its Endako Mine Division. British Columbia Molybdenum had produced at a capacity rate of 6 million pounds a year; Endako output was cut back in March to about 50 per cent of its capacity of 18 million pounds a year. New production came from the large low-grade copper-molybdenum operations of Utah Mines Ltd. on Vancouver Island and of Lornex Mining Corporation Ltd. in the Highland Valley area, B.C.

Outlook

World consumption and production likely will be reasonably balanced by 1974 but supply throughout the remainder of the decade will depend largely on expansion plans of the major producers. With the gradually rising steel demand apparent in 1972, the long-term traditional annual growth in demand for molybdenum of about 7 per cent a year is reasonable to project demand for the remainder of the decade. A major increase in production capacity, being developed at the Henderson mine of American Metal Climax, Inc. (AMAX) in Colorado is scheduled for initial production after the mid-70's; an eventual production rate of 50 million pounds of molybdenum a year is planned, possibly in the late 1970's or early 1980's. World annual production capacity apparently will continue to exceed consumption by 15-20 per cent until 1977 and perhaps until 1980.

Production and developments

Canada. Production (shipments) of molybdenum in Canada rose meteorically from 1.2 million pounds in 1964 to 20.6 million pounds in 1966 and 33.7 million pounds in 1970. The increase in 1965 was due to initial production from two significant primary producers in British Columbia – Endako Mines Ltd., Endako Mine (now Endako Mine Division of Canex Placer Limited), and the Boss Mountain property of Brynnor Mines Limited. Before Brenda Mines Ltd. began producing at its mine near Kelowna, B.C. in late 1969, Canadian coproduct or byproduct output from large-tonnage low-grade copper-molybdenum deposits was not significant. In 1972, about one half of Canada's molybdenum production was recovered as secondary product with copper. The increase in proportion was the result of production cutbacks and closure of primary molybdenum operations during 1971 and 1972 coupled with increased byproduct production from the start-up of new copper-molybdenum operations.

Production

Brenda Mines Ltd., with mine operations 24 miles west of Kelowna, British Columbia, produced 10 million pounds of molybdenum in 1972 contained in 8,975 tons of concentrates grading 55.97 per cent molybdenum. Ore milled totalled 9,503,190 tons at a rate of 25,965 tons of ore a day, and recovery of molybdenum was 86.06 per cent. During the year, 6.6 million pounds of molybdenum were sold and the inventory increased by 3.4 million pounds to 11.0 million pounds at December 31, 1972. Ore reserves at

* Excluding China and U.S.S.R.

Table 1. Canada, molybdenum production, trade and consumption, 1971-72

	1971		1972^p	
	(pounds)	($)	(pounds)	($)
Production (shipments)[1]				
British Columbia	21,884,729	36,954,846	23,975,000	32,545,000
Quebec	778,003	1,412,498	869,000	1,477,000
Total	22,662,732	38,367,344	24,844,000	34,022,000
Exports				
Molybdenum in ores and concentrates				
Belgium and Luxembourg	1,368,400	2,479,000	13,939,300	27,189,000
Britain	5,784,300	10,995,000	5,930,300	10,901,000
Japan	3,939,200	8,623,000	3,870,500	8,049,000
Netherlands	5,359,500	10,907,000	4,092,200	7,621,000
Sweden	1,153,000	2,173,000	725,800	1,123,000
West Germany	771,300	1,385,000	709,900	1,025,000
France	2,999,300	5,561,000	461,700	716,000
Brazil	221,500	451,000	353,400	712,000
India	102,800	174,000	300,400	663,000
United States	8,400	14,000	241,700	533,000
Italy	915,900	1,559,000	288,500	446,000
Other countries	321,200	584,000	415,600	788,000
Total	22,944,800	44,905,000	31,329,300	59,766,000
Imports				
Molybdic oxide (gross weight)	64,600	97,000	26,700	36,000
Molybdenum in ores and concentrates[2] (Mo content)	1,352,540	2,372,468	337,953[4]	617,622[4]
Ferromolybdenum[2] (gross weight)	183,156	253,168	54,790[4]	107,241[4]
Consumption (Mo content)				
Ferrous and nonferrous alloys	1,684,153	. .	. .	. .
Electrical and electronics	13,428	. .	. .	. .
Other uses[3]	117,005	. .	. .	. .
Total	1,814,586	. .	. .	. .

Source: Statistics Canada, except where noted.
[1] Producers' shipments (Mo content) of molybdenum conc., molybdic oxide and ferromolybdenum. [2] U.S. exports of molybdenum to Canada, reported by U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), value in U.S. currency. These imports not available separately in official Canadian trade statistics. [3]Chiefly pigment uses. [4]First 10 months only.
^{p}Preliminary; . . Not available.

the end of 1972 were 145.2 million tons grading 0.180 per cent copper and 0.048 per cent molybdenum. Leaching of molybdenum concentrates to remove impurities was resumed in November 1972 to restore the working inventory of leach concentrate.

British Columbia Molybdenum Limited, a subsidiary of Kennecott Copper Corporation, ceased operations on April 28, 1972 at its mine and mill near Alice Arm, B.C. The 6,000-ton-a-day mill started regular operation in January 1968; it produced 5.1 million pounds of molybdenum during 1971. A continued deterioration in both molybdenum price and sales volume made the operation unprofitable. Production in 1972 was 1.06 million pounds of molybdenum.

Endako Mines Division of Canex Placer Limited operates the largest molybdenum mine in Canada, near Endako, British Columbia. Production was reduced to about 50 per cent of the 1970 level of 18.2 million pounds of molybdenum a year in March 1972, following a previous reduction to 75 per cent. Cutbacks were made to bring production into better balance with shipments and to reduce a large inventory of unsold molybdenum concentrates that had accumu-

Table 2. Canada, molybdenum production, trade and consumption, 1962-72

	Production[1]	Exports[2]	Imports		Consumption[5]
			Molybdic Oxide[3]	Ferro-molybdenum[4]	
1962	817,305	. .	328,424	121,358	1,261,380
1963	833,867	. .	258,765	125,869	1,306,193
1964	1,224,712	. .	490,500	271,605	1,261,454
1965	9,557,191	. .	759,500	398,460	1,702,589
1966	20,596,044	. .	665,500	522,800	1,261,387
1967	21,376,766	23,792,700	452,600	316,692	1,430,895
1968	22,464,273	22,704,500	1,359,300	284,600	1,543,432
1969	29,651,261	25,672,600	76,600	482,609	1,808,772
1970	33,771,716	30,334,000	73,900	65,299	2,286,061
1971	22,662,732	22,944,800	64,600	183,156	1,814,586
1972^p	24,844,000	31,329,300	26,700	54,790[6]	

Source: Statistics Canada, except where noted.
[1]Producers' shipments (Mo content) molybdenum conc., oxide and ferromolybdenum. [2]Mo content, ores and conc. [3]Gross weight. [4]U.S. exports to Canada reported in U.S. Exports of Domestic and Foreign Produce, gross weight. [5]Mo content of molybdenum products reported by consumers. [6]First 10 months 1972.
^{p}Preliminary; . . Not available.

lated as a result of depressed molybdenum markets. Production during 1972 was 9,237,000 pounds of molybdenum consisting of 1,674,000 pounds in molybdenite concentrates and 7,563,000 pounds in molybdic oxide. The mill throughput averaged 24,150 tons a day with a recovery of 81.2 per cent. The roaster, which produces molybdic oxide, operated at capacity. Proven and probable reserves at the Endako pit at December 31, 1972 totalled 188.5 million tons grading 0.143 per cent MoS_2 at 0.08 per cent cutoff grade; at the company's adjacent Denak pit reserves were 5.4 million tons grading 0.232 per cent MoS_2 at 0.10 per cent cutoff grade. At year-end, inventory had been reduced to 7,947,000 pounds, compared with 10,038,000 pounds at the end of 1971.

In March 1973, Canex Placer announced that full production will resume at the Endako mine because the mine's inventory was approaching more acceptable levels as a result of higher demand in world markets. Production was expected to reach an annual rate of 15 million pounds of molybdenum by June 1, 1973. Additional flotation cells are planned for the mill circuit to increase retention time and to give better recovery of molybdenum.

Lornex Mining Corporation Ltd., managed by Rio Algom Mines Limited, commenced mill tune-up in April at its open-pit copper-molybdenum mine, 33 miles south of Ashcroft, in Highland Valley area, B.C. Byproduct molybdenum recovery began in August and during the production period following October 1, the milling rate was about 31,000 tons a day; design capacity is 38,000 tons a day. Production in 1972 amounted to 654,000 pounds of molybdenum in concentrates. Annual production capacity has been estimated at 54,000 tons of copper and 2,300 tons of molybdenite concentrate averaging 54 per cent molybdenum (2.4 million pounds of molybdenum). Prior to production, the company negotiated a five-year contract for the sale of the projected annual output of molybdenum concentrates with Phillip Brothers, New York, N.Y., a division of Engelhard Minerals & Chemicals Corporation. The mine-mill operation was brought into production at a capital cost of $142.7 million. When operations began, ore reserves were estimated at 292.8 million tons averaging 0.427 per cent copper and 0.014 per cent molybdenum.

Utah Mines Ltd., a wholly owned subsidiary of Utah International Inc., completed its first production year following commencement of tune-up operations in October 1971 at its Island Copper open-pit copper-molybdenum mine near Port Hardy, Vancouver Island. In June, the mill attained design capacity of 33,000 tons a day. Output during the year included 250 tons of byproduct molybdenum concentrates. Annual capacity production has been estimated at 55,000 tons of copper and 1.9 million pounds of molybdenum. The company estimated reserves at 250 million tons averaging 0.52 per cent copper and 0.029 per cent molybdenite when operations commenced.

King Resources Company, Denver, Colorado, continued operations at its Mount Copeland property, near Revelstoke, B.C. Red Mountain Mines Limited closed its molybdenum operations at Red Mountain near Rossland, B.C. in January, 1972.

In Quebec, Gaspé Copper Mines, Limited produced 206,000 pounds of molybdenum in concentrate as a byproduct of its copper mining operations near Murdochville on the Gaspé Peninsula. Production in 1971 was 407,000 pounds of molybdenum in concentrate. Production facilities were expanding greatly during the year which will triple mill capacity to 34,000 tons a day and thereby significantly increase copper and byproduct molybdenum output.

Molybdenite Corporation of Canada Limited closed its mine and mill near Lacorne, Quebec, in September after the operation was financially assisted for about one year by the provincial government.

Development

Gibraltar Mines Ltd., a subsidiary of Placer Development Limited, commenced tune-up operations in March at its copper-molybdenum mine near McLeese Lake, in the Cariboo District, B.C. Although the mill design capacity was 30,000 tons a day, it averaged 39,500 tons a day during the nine-month operating period ending December 31, 1972. The molybdenum circuit was operated on a trial basis for a short period to delineate operating parameters but the average molybdenum content of the ore processed was considered to be below economic recovery levels. However, molybdenum will be recovered when there is an economic quantity present in the mill feed. Ore reserves at December 31, 1972 were estimated at 347 million tons averaging 0.371 per cent copper and 0.016 per cent molybdenite (MoS_2). Preproduction capital expenditures were $67 million.

Among copper-molybdenum properties in British Columbia studied for their production possibilities in 1972 were the following: Bethlehem Copper Corporation Ltd's J-A zone 25 miles southeast of Ashcroft in the Highland Valley area and Highmont Mining Corp. Ltd's property, 4 miles south of the Bethlehem property. The J-A deposit is close to Bethlehem's producing copper mine with a 16,000-ton-a-day mill. Reserves of the J-A zone were estimated at 300 million tons grading 0.45 per cent copper equivalent including 100 million tons grading 0.603 per cent copper and 0.018 per cent molybdenum at a stripping ratio of approximately 2.5 to 1.

On the Highmont property, reserves were estimated at 150 million tons grading 0.285 per cent copper and 0.051 per cent molybdenite (MoS_2).

During February 1973, Adanac Mining and Exploration Ltd. announced that it had entered into agreement with Climax Molybdenum Corporation of British Columbia, Limited, a subsidiary of American Metals Climax, Inc., to carry out further exploration and development of Adanac's Ruby Creek molybdenite deposit near Atlin, B.C. Climax will conduct a production feasilibity study and decide whether to make a production commitment prior to December 31, 1975. Open pit reserves were estimated at 104.2 million tons averaging 0.16 per cent MoS_2 in 1971.

Table 3. Molybdenum production[1] in ores and concentrates, 1970-72

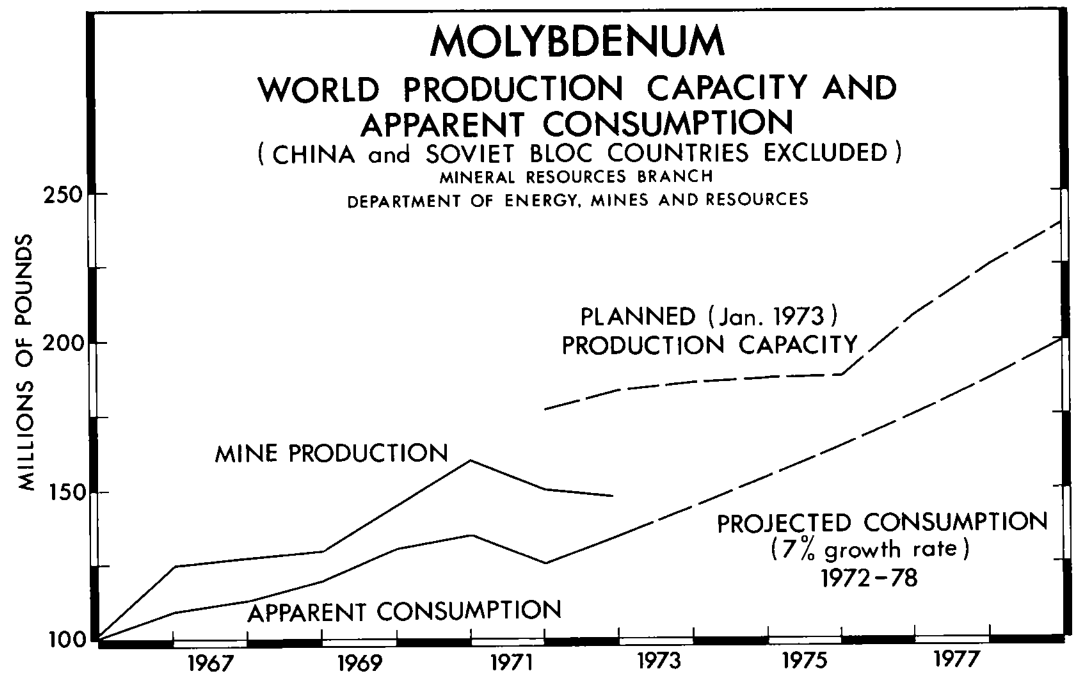
	1970	1971	1972^p
	(Mo content, 7,000 pounds)		
United States	111,352	109,592	105,421
Canada (shipments)	33,772	22,663^r	24,844^p
Chile	13,448^r	13,889	14,500
Peru	1,167	1,781	1,500
South Korea	254	234	
Japan	974^r	586	
Norway	553^r	794	1,900
Mexico	311	174	
Philippines	71	50^e	
Total	161,902	149,763	148,165

Source: U.S. Bureau of Mines, *Minerals Yearbook 1971.*
[1]Excludes U.S.S.R. and China.
^{e}Estimated; ^{r}Revised; ^{p}Preliminary.

United States. United States output of molybdenum in 1972 declined for the second consecutive year. Mine production of molybdenum in concentrates totalled 105.4 million pounds in 1972 compared with 109.6 million pounds in 1971. Industrial stocks of molybdenum were the larger on record at year-end; exports of molybdenum dropped for the fourth consecutive year. Foreign markets received about 43 per cent of domestic production with the principal importing countries being the Netherlands, Japan, West Germany, Belgium and Luxembourg. Canada received 386,000 pounds of molybdenum contained in concentrate and roasted concentrate.

On June 30 the United States government stockpile of molybdenum contained 46.7 million pounds of molybdenum in the following forms: molybdenite concentrates, 28.2 million pounds; ferromolybdenum, 7.5 million pounds; and molybdic oxide, 11.0 million pounds. The United States Office of Emergency Preparedness (OEP) in 1971 declared all molybdenum in the stockpile in excess of national emergency needs since abundant supplies are available from producers if needed. Disposal of the surplus molybdenum requires legislative approval by Congress.

Climax Molybdenum Division of American Metals Climax (AMAX) is the world's largest producer of molybdenum with an output of about 60 million pounds of molybdenum in 1972 from its Climax and Urad mines in Colorado. Amax started a $40 million project in 1972 to develop surface mining operations and thus increase production of its main Climax molybdenum mine in Colorado. Mine production will be raised from the current 43,000-ton-a-day capacity to 60,000 tons a day in 1974 in time to phase out the smaller Climax Urad mine as its reserves become exhausted. Amax estimates that open pit mining will



increase present molybdenum reserves at the Climax site by 90 million tons with an average grade of 0.21 per cent MoS_2.

Of major significance to the world industry is the expansion of molydenum production being developed by Amax at its Henderson property in Colorado. This project is scheduled to come on stream after the mid-1970's; the planned production capaticy of 50 million pounds of molybdenum a year could be developed by 1980. This schedule could be delayed to minimize oversupply in the industry. During 1973 mine development will be advanced further. Proven and probable reserves are approximately 300 million tons grading 0.49 per cent MoS_2.

Molybdenum Corporation of America (Molycorp), the second largest primary producer of molybdenum in the United States, produced 10.98 million pounds of molybdenum at its Questa mine in New Mexico. Production in 1973 could be less since lower prices and rising inventories necessitated a lower production rate at the Questa mine early in 1973.

Kennecott Copper Corporation produced 13.98 million pounds of byproduct molybdenum in 1972 from its United States copper operations compared with 13.35 million pounds the previous year.

Duval Corporation's Esperanza copper-molybdenum mine in Arizona reopened in January 1973 following suspension of production in December 1971. The Esperanza mine produces 2 to 2.2 million pounds of molybdenum a year. Molybdenum sales from the Duval Sierrita Corporation's open-pit copper-molybdenum mine in Arizona and inventories in 1972 totalled 16.6 million pounds.

Uses

Additions of molybdenum promote uniform hardness, hardenability and toughness in many types of steel. Molybdenum is added to molten steel in the form of molybdic oxide or as ferromolybdenum. It raises the tensile strength and creep resistance of low- and high-alloy steel for use at high temperatures. High-strength low-alloy (HSLA) linepipe steel containing 0.24 per cent molybdenum and 0.042 per cent carbon is being used in Canadian natural gas pipelines. Molybdenum improves the corrosion resistance of chromium-nickel and high-chromium stainless steel giving a superior product for the handling of chemicals. In abrasion-resistant cast manganese steel, the addition of about 1 per cent molybdenum makes possible the use of higher threshold carbon contents before embrittlement will occur. Molybdenum also improves the high-temperature strength and toughness of cast iron and stainless steel. Molybdenum is used in alloy tool steels and high-speed steels to attain greater hardness and toughness.

Molybdenum-containing catalysts are used in the petroleum and chemical industries to desulphurize petroleum products and chemicals. Molybdenum is

Table 4. The Canadian molybdenum industry, 1971-72

Company and Mine Location	Mill Capacity[1] Ore Grade, 1972	Product	Production Contained Molybdenum 1971	1972	Remarks
	(%)		('000 pounds)		
British Columbia					
Brenda Mines Ltd., Peachland	26,000 Cu 0.208, Mo 0.061	coproduct concentrate	9,600	10,046	Inventory of 11 million pounds at December 31, 1972
British Columbia Molybdenum Limited, Alice Arm	6,000 ..	primary concentrate	5,107	1,061	Production ceased April 1972
King Resources Company, Revelstoke	230	primary concentrate	969	..	
Lornex Mining Corporation, Ltd., Ashcroft	38,000	byproduct concentrate	na	654	Production tune-up commenced in April 1972
Canex Placer Limited, Endako Division, Endako	28,000 Mo 0.149	primary concentrate and oxide	14,338	9,237	Inventory of 7.95 million pounds at December 31, 1972
Utah Mines Ltd., Port Hardy	33,000	byproduct concentrate	407 ..	275[e]	Production tune-up commenced October 1971
Quebec					
Gaspé Copper Mines, Limited, Murdochville	34,000 ..	byproduct concentrate	407	260	Production capacity increased during 1972
Molybdenite Corporation of Canada Limited, Lacorne	100 ..	primary concentrate	..	–	Production ceased September 1972

Source: Company reports.
[1] Design capacity in tons of ore a day.
.. Not available; na Not applicable; – Nil; [e]Estimate.

also used in the production of pigments. Molybdenum metal and molybdenum-base alloys are used in high-temperature applications, thermocouples, electronics, missile parts and in structural parts of nuclear reactors.

Prices

Molybdenum has had a long record of price stability established by Amax for its molybdenum products. In 1972 byproduct producers continued to sell at discount prices as much as 20 per cent below that established by Amax for its molybdenum products. The U.S. price established by American Metals Climax, Inc., on May 5, 1969 remained unchanged through 1972 at $1.72 a pound of contained molybdenum in concentrates and $1.91 a pound of contained molybdenum in molybdic oxide (MoO_3). Kennecott Copper Corporation and other byproduct producers marketed standard (high-purity) and high-copper molybdic

Table 5. United States, molybdenum concentrate

	1971	1972
	('000, pounds contained molybdenum)	
Production	109,592	105,421
Shipments[1]	97,882	91,147
Consumption[2]	66,399	62,393
Stocks, mine and plant	29,077	40,751
Exports	46,284	45,362

Sources: United States Bureau of Mines, *Minerals Yearbook 1971*, Mineral Industry Surveys, December 1972.
[1]Includes exports. [2]Quantity converted to technical-grade molybdic oxide.

oxide at lower prices. On January 1, Kennecott reduced its U.S. price of MoO_3 by 7 cents a pound to \$1.84 a pound of contained molybdenum for its high-purity K-1 grade oxide and to \$1.77 a pound of contained molybdenum for its high-copper K-2 grade oxide in bags, fob shipping point. It was reported by *Metals Week* that prices of Kennecott oxides were further reduced in November to \$1.77 for K-1 grade and \$1.71 for K-2 grade.

Table 6. United States consumption of molybdenum by end use

	('000 pounds) contained molybdenum)		('000 pounds) contained molybdenum)
Carbon steel	2,190	Other alloys and nonferrous alloys	633
Stainless and heat resisting	4,944	Mill products made from metal powder	2,122
Alloy steel	17,218	Chemical and ceramic uses	
Tool steel	2,241	Pigments	1,079
Cast irons	3,483	Catalysts	1,407
Superalloys	1,728	Other	797
Cutting- and wear-resistant materials	..	Miscellaneous and unspecified	2,729
Welding and hardfacing rod and materials	376	Total	40,950[1]

Source: United States Bureau of Mines *Minerals Yearbook 1971*, Preprint. [1] Data may not add to totals shown because of independent rounding.

Prices of contained molybdenum, fob shipping point, as reported in Metals Week

	Jan. 11, 1967	May 5, 1969	Dec. 31, 1971	Dec. 31, 1972
	(U.S. \$ per pound)			
Molybdenum concentrates, 95% MoS_2, containers extra, molybdic oxide (MoO_3)	1.62	1.72	1.72	1.72
In bags	1.81	1.91	1.91	1.91
In cans	1.82	1.92	1.92	1.92
Ferromolybdenum, 0.12-0. 25% C, 5,000 lb lots				
Lump	2.11	2.21	2.21	2.21
Powder	2.17	2.27	2.27	2.27
Molybdenum powder, hydrogen reduced, 99.95% Mo	..	3.73	4.00	..

.. Not available.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
32900.1	Molybdenum ores and concentrates	free	free	free
35120.1	Molybdenum and alloys in powder, pellets, scrap, ingot, sheets, strip, plate, bars, rods, tubing and wire for use in Canadian manufactures, (expires October 31, 1973)	free	free	25
92828.1	Molybdenum oxides and hydroxides	10	15	25
37506.1	Ferromolybdenum	free	5	5
37520.1	Calcium molybdate	free	free	5

United States

Item No.		On and After 1971	January 1 1972
		(¢ per lb on Mo content)	
601.33	Molybdenum ores and concentrates	14	12
418.26	Calcium molybdate	12 + 3.5%	10 + 3%
419.60	Molybdenum compounds	12 + 3.5%	10 + 3%
628.72	Molybdenum metal, unwrought	12 + 3.5%	10 + 3%
607.40	Ferromolybdenum	12 + 3.5%	10 + 3%
		(%)	(%)
628.74	Molybdenum metal, wrought	15	12.5
628.70	Molybdenum metal, waste and scrap (suspended)	12.5	10.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Natural Gas

J. W. FRASER

Production and consumption of natural gas in Canada in 1972 continued to follow a strong upward trend. Net withdrawals increased by 16.5 per cent to 2,913,045 MMcf* or 7,981 MMcf/d, compared with the 9.8 per cent growth experienced in 1971, when production averaged 6,851 MMcf/d. Canadian customers used 1,145,797 MMcf, or 3,139 MMcf/d, of which more than half was accounted for by sales in the industrial category. Exports to the United States rose by 10.6 per cent to 2,766 MMcf/d, but the rate of export growth was considerably lower than in recent years because no new exports have been approved since 1970. Imports from the United States remained at essentially the same level as in 1971, averaging 43 MMcf/d.

The high rates of production and consumption made heavy demands on Canada's existing proved reserves. In spite of increased exploratory and development activity in many areas, proved natural gas reserves declined for the first time since the Canadian Petroleum Association (CPA) began making annual estimates in the early 1950's. Proved remaining marketable reserves of natural gas were estimated to be 52,935,782 MMcf at the end of 1972, a decrease of 4.6 per cent from the previous year. Significant gas discoveries were reported from the Mackenzie Delta, the Arctic islands and off the east coast, but potential reserves in these areas are not included in the CPA estimates since no transportation facilities are available to move gas from these sources to market. However, considerable research has been done on determining and solving the technical, social and ecological problems of northern pipelines and an application is expected to be made in 1973 requesting permission to construct a major gas pipeline from the Mackenzie Delta area.

The pricing of natural gas supplies came under investigation in 1972 following a study commissioned by the Alberta government to look into the factors which influence the wellhead price of natural gas in Alberta, and the suitability of such practices in relation to the provincial interest. As a result of the study, the Alberta government has outlined new policies designed to obtain greater financial benefits from provincial natural gas resources, including proposals to substantially raise the wellhead price of gas and to provide for more frequent price redetermination. Since Alberta provides much of the gas used in Canada, wellhead price increases will lead to consumer price increases, as approval for higher gas rates are received from regulatory authorities.

Production

Net withdrawals from producing fields rose by 16.6 per cent in 1972 to 2,913,047 MMcf, for an average of 7,981 MMcf/d. This was a substantial growth over 1971, when production increased by 9.8 per cent and production averaged 6,851 MMcf/d. Alberta continued to provide over four fifths of the marketable gas in Canada – something it has been doing for at least a decade. British Columbia continued to supply about 15 per cent of Canadian marketable gas, a level it reached in 1967. Both provinces have continued to expand production from the inception of principal, interprovincial pipelines. Significantly, in 1972, net natural gas production from the Northwest Territories was substantially expanded as a result of a new pipeline extension from northeastern British Columbia to the Pointed Mountain field in the southwest corner of the Territories. Output from Saskatchewan and Ontario was consumed within the province of production. The trend of output from Ontario has been downward for at least the last decade and the proportion of national total of marketable gas has dropped from 1.6 per cent in 1962 to 0.4 per cent in 1972. Saskatchewan's output in absolute terms had been increasing year by year until 1972 when the first decline in output was registered. In spite of the steady increase in output it has not been keeping pace with national growth. Saskatchewan's share of the national total fell from 4.1 per cent in 1962 to 2.3 per cent in 1972.

Table 2 shows the amount of gas which was produced and later reinjected into a producing reservoir either as a conservation measure to increase the ultimate recovery of liquid hydrocarbons, or as part of distributors' storage operations. The Kaybob South field is an example of a conservation scheme to maximize ultimate recovery of the liquid constituents of field gas. Here, gas is produced and processed to remove the liquid hydrocarbons and sulphur, after which most of the residue gas is reinjected to maintain pressure in the original producing reservoir. This operation is to ensure the maximum possible recovery of natural gas liquids before the reservoir is depleted by the sale of the gas. Similarly, natural gas may be

*MMcf = 1,000,000 cubic feet. MMcf/d = 1,000,000 cubic feet per day.

Table 1. Canadian natural gas fields producing 10 million Mcf or more, 1971-72[1]

(numbers in brackets refer to map locations)	1971 (Mcf)	1972 (Mcf)		1971 (Mcf)	1972 (Mcf)
Alberta			Carson Creek (13)	27,401,853	20,444,361
Kaybob South (25)	107,036,467	233,232,850	Alderson (10)	14,071,950	18,041,611
Crossfield (1)	157,710,434	158,464,089	Hussar (16)	18,715,968	17,829,790
Waterton (11)	92,829,621	148,011,507	Bigstone (25)	18,476,865	17,568,897
Edson (19)	104,855,819	112,332,520	Pine Creek (6)	16,627,350	17,117,760
Strachan (24)	70,973,782	112,166,610	Jumping Pound (17)	18,376,792	16,256,157
Westerose South (2)	92,446,598	88,294,063	Wimborne (12)	15,161,814	15,786,604
Windfall (5)	61,749,368	68,506,660	Viking-Kinsella (38)	16,093,557	13,917,053
Jumping Pound West (17)	41,107,454	64,530,769	Fort Saskatchewan (21)	13,393,910	13,606,705
Medicine Hat (10)	58,408,954	63,981,930	Bindloss (26)	14,753,799	13,482,224
Harmattan Elkton (8)	49,775,970	63,128,991	Bonnie Glen (22)	10,858,628	13,185,243
Crossfield East (1)	58,765,136	56,498,282	Swan Hills South (13)	10,472,101	13,107,253
Ricinus West (24)	–	55,648,371	Olds (12)	13,442,187	12,882,095
Harmattan East (8)	54,190,550	53,851,992	Burnt Timber (20)	9,680,635	12,674,381
Homeglen-Rimbey (9)	51,589,250	50,169,120	Craigend (27)	9,559,217	12,659,891
Carstairs (12)	45,515,514	49,296,115	Countess (16)	12,103,510	12,482,369
Marten Hills (27)	46,585,466	48,276,078	Leduc-Woodbend (22)	9,427,341	11,900,264
Brazeau River (37)	45,074,337	47,159,152	Wayne-Rosedale (3)	12,411,535	11,469,091
Gilby (9)	44,653,479	46,854,919	Carson Creek North (13)	8,504,826	11,377,728
Pembina (7)	47,878,145	46,167,579	Turner Valley (18)	12,350,423	10,427,881
Nevis (14)	41,127,918	44,610,904	Atlee-Buffalo (26)	10,634,212	10,004,811
Cessford (4)	46,916,812	44,535,215			
Provost (15)	41,795,492	41,013,368	**British Columbia**		
Wildcat Hills (20)	37,135,014	34,869,441	Clarke Lake (35)	104,278,387	104,204,239
Ferrier (8)	34,159,999	34,212,335	Yo Yo (31)	37,462,939	68,259,702
Kaybob (25)	31,931,890	31,565,311	Beaver River (33)	12,520,830	68,251,540
Minnehik-Buck Lake (23)	25,381,260	28,592,820	Rigel (34)	22,805,490	24,471,087
Ghost Pine (28)	26,742,698	26,575,010	Laprise Creek (30)	24,175,857	23,567,368
Rainbow (39)	19,540,601	23,859,247	Sierra (31)	15,969,175	16,811,280
Quirk Creek (18)	22,020,011	23,671,030	Nig Creek (32)	17,756,522	15,123,824
Sylvan Lake (2)	22,178,062	23,493,926	Jedney (30)	16,764,879	14,485,528
Lone Pine Creek (1)	15,250,404	22,497,208	Stoddart (34)	15,602,264	13,943,636
Judy Creek (13)	21,316,793	21,992,600	Buick Creek (32)	11,246,207	9,767,941
Westlock (21)	18,474,273	21,371,589			
Swan Hills (13)	17,648,812	20,952,107	**Saskatchewan**		
Lookout Butte (3)	21,770,492	20,584,867	Coleville-Smiley (36)	11,622,481	7,342,189

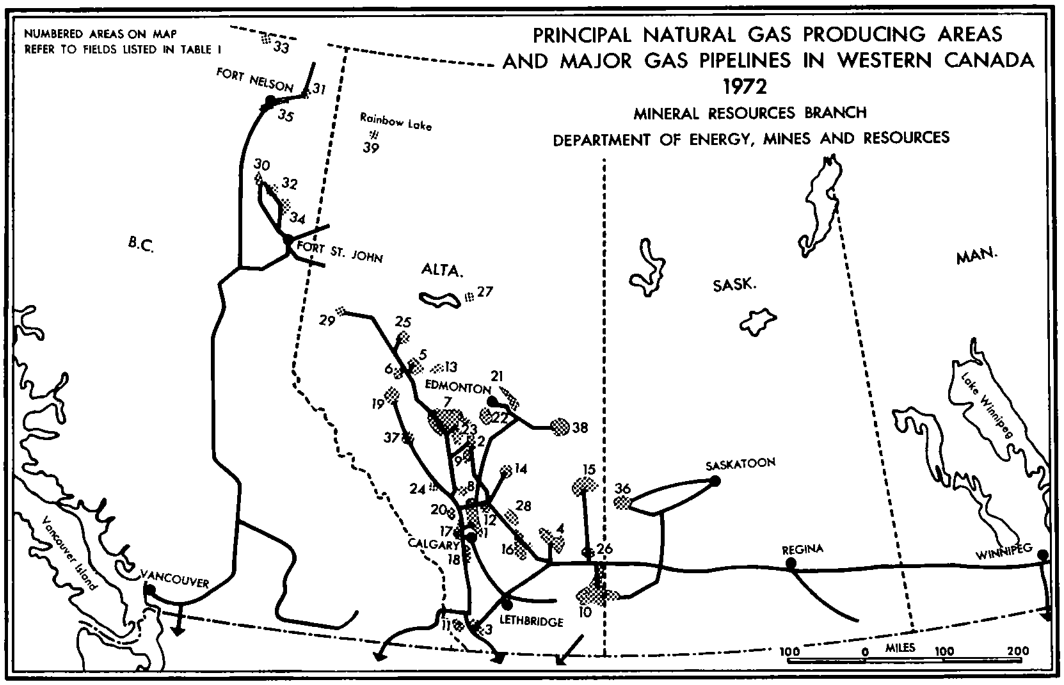
Source: Provincial government reports.
[1] 14.65 psia. – Nil.

temporarily reinjected into producing oil reservoirs thereby maintaining reservoir pressure to maximize production of crude oil where this is possible.

The volumes shown as distributors' storage represent gas which is stored by gas utilities during low-demand periods, usually in summer, and is later withdrawn as required to meet peak demands in winter. This helps to level out the utilities' demand on the trunk carriers over the year. In Alberta and Ontario most of the gas is stored in former producing fields which have been depleted. However, in Saskatchewan much of the storage is in large, manmade, subsurface caverns which have been leached from salt beds specifically to provide storage facilities near major consuming areas.

Exploration and development

Alberta. Faced with the prospect of continuing strong demands and increased wellhead prices for both oil and gas, producers in the province substantially increased their efforts to develop new reserves. As a result, both total well completions and total footage drilled increased with the largest increase being recorded in the development sector. Almost half of all



development wells drilled were successful gas wells, most of which were completed in the approximate depth range of from 1,000 to 4,000 feet. Much of the development was in the many producing fields in the plains areas of central and southeastern Alberta. Fields here generally have relatively dry, sulphur-free gas which can be marketed easily because of the extensive existing pipeline networks. One of the most active areas, in terms of wells drilled, has been Medicine Hat - Alderson where several hundred closely spaced wells have been drilled each year over the last several years to develop shallow, low-pressure gas reservoirs.

Improved economics resulting from higher gas prices made drilling in the Foothills and deep basin areas of western Alberta more attractive. Although the prospects for large discoveries are better here than in the plains, operations are much more expensive because of factors such as remote locations and deeper drilling requirements. This situation has been compounded in recent years by the mounting costs of removing sulphur, a common element in many Foothills fields, and concurrent low prices for sulphur.

Early in 1972, a dual zone gas discovery was made at Suffolk Plains Coleman 4-23-9-4 W5, located 20 miles northwest of the Waterton field in southwestern Alberta. Subsequent testing indicated that the well has a potential deliverability of about 9 million cubic feet daily from the Devonian Palliser formation and 12 MMcf/d from Mississippian formations. Another Mississippian discovery was reported west of Calgary at Phillips Ghost 4-36-26-8W5, located 6 miles west of the Jumping Pound West field. Two separate zones were reported to have tested up to 18.5 MMcf/d. An indication of the potential size of discoveries in these areas was given by the Albany Amoco Ricinus 1-15-34-8W5 discovery in the Ricinus area, approximately 65 miles northwest of Calgary. The well encountered a full reef buildup in the Devonian Leduc Formation containing more than 450 feet of net pay zone. Tests of the upper 200 feet indicate an absolute open flow potential of 460 MMcf/d of gas. Another Leduc reef discovery was reported at Husky et al Strachan E 11-23-37-8W5, which is located 20 miles north of the Albany well and 5 miles east of the Strachan field. No production data was reported by year-end. A six-mile northeastern extension of the Brazeau River field was indicated by a new Mississippian discovery, HB BRAZR 11-25-47-13W5. Further evaluation was continuing at year-end in the Fir area between the Pine North West and Bigstone fields, 140 miles west of Edmonton, following three gas discoveries made by the team of Petrofina Canada Ltd., Hudson's Bay Oil and Gas Company Limited and Amoco Canada Petroleum Company Ltd. The discoveries were reported to be in Triassic formations which have not previously been productive in this immediate area. Further drilling was also planned to evaluate a new gas discovery at GCON et al Teepee

10-21-73-3W6, approximately 35 miles northwest of the Sturgeon Lake field in west-central Alberta. The well was reported to be a dual zone, Upper Devonian discovery which had an absolute open flow potential of 19 MMcf/d on test.

In eastern Alberta, potential production capability was indicated in several discoveries north and east of the Pelican, Martin Hills and Calling Lake fields which are the northernmost fields in this part of the province. In the northwestern part of the province, several discoveries were reported north and east of the Worsley field. Exploration for gas in this area has been encouraged by the conversion of a former oil pipeline, which ran south from the Zama Lake field to Valleyview, to use as a gas pipeline for The Alberta Gas Trunk Line Company Limited system. At year-end there were 3,318 operating gas wells in the province, of 3,984 capable of production.

British Columbia. Both the footage drilled and the number of wells completed increased in 1972. Exploratory gas discoveries were almost double the 1971 level and development gas well completions were up by 50 per cent.

Progress towards the outlining of a new productive region was made by continued drilling in the Grizzly Valley region of northeastern British Columbia, approximately 100 miles south of Fort St. John. Early in 1972, gas was found in the Triassic Nikanassin Formation at Monkman Pass by the well PRP Grizzly c-36-A93-I-15, located 1 mile northwest of a suspended gas well drilled in 1964. Later in the year, three separate gas zones were found in Triassic formations at Quasar Grizzly a-74-G-93-I-15, located 9 miles to the northwest of the earlier discovery. One successful development well was completed and at year-end further drilling was under way to establish the gas reserves necessary to justify a pipeline connection to the area.

Wells were completed in and near the many existing fields in the established producing area which extends north and northwest from Fort St. John, where production is obtained from Cretaceous, Triassic and Mississippian rocks. North of this producing area, Mississippian gas discoveries were reported from three exploratory wells south of the Clark Lake field, southeast of the Sierra field, and in the Bivouac area near the Alberta border; no details were released. Development continued on the chain of gas fields which stretch north from Fort Nelson, obtaining production from the Middle Devonian Slave Point Formation. One well, BP et al Gote d-37-D-94-P-12, located 5 miles northwest of the Tsea field, was

Table 2. Pressure maintenance projects and storage of natural gas in Canada, 1971-72

	1971 Input (Mcf)	1972^p Input (Mcf)		1971 Input (Mcf)	1972^p Input (Mcf)
Alberta			Rainbow	11,172,236	11,611,128
Aerial	150,003	261,710	Rainbow South	856,635	706,051
Ante Creek	1,689,502	1,584,772	Redwater	564,774	335,740
Bigstone	496,048	835,235	Rowley	2,201,317	424
Bonnie Glen	133,892	614,166	Turner Valley	55,464	55,930
Carbon	–	392,275	Waterton	11,626,223	13,294,717
Carson Creek	11,336,156	11,872,565	Westerose South	6,119,054	5,582,935
Carstairs	1,421,921	2,923,776	Willesden Green	1,690,872	1,191,835
Crossfield	3,862,926	5,910,403	Windfall	19,386,106	20,268,425
Crossfield East	2,999,418	640,867	Wizard Lake	5,699,073	10,435,068
Duhamel	221,202	226,521			
Gilby	444,570	87,263	Total (14.65 psia)	237,164,269	313,549,149
Golden Spike	8,712,662	12,269,718	Total (14.73 psia)	235,883,582	311,855,984
Harmattan East	43,542,758	42,713,542			
Harmattan Elkton	36,652,430	42,753,365	**Ontario**	78,638,635	76,638,840
Joarcam	1,325,640	1,450,330			
Judy Creek	2,392,923	691,704	**Saskatchewan**		
Kaybob South	57,920,108	115,345,830	(14.73 psia)	5,090,015	6,517,666
Leduc-Woodbend	2,035,620	5,402,070			
Mitsue	171,755	451,427	Total, Canada		
Pembina	2,282,981	3,639,357	(14.73 psia)	319,612,232	395,012,490

Source: Provincial government reports.
^{p} Preliminary; – Nil.

reported to have produced at the rate of 49 MMcf/d on test. In addition, the team of Canadian Reserve Oil and Gas Ltd. and Quintana Exploration Co. made significant field extensions in the Kotcho Lake - Yoyo gas producing area during the 1972-73 winter drilling season.

There was no drilling in the Pacific offshore region during the year. Offshore acreage held by companies under federal permits decreased by about 300,000 acres to 16.0 million acres. At the end of 1972, there were 816 gas wells capable of production in the province, of which 321 were in operation.

Table 3. Canada, production of natural gas, 1971-72[1]

	1971		1972^p	
	(Mcf)	($)	(Mcf)	($)
Gross new production				
New Brunswick	105,114		97,114	
Quebec	170,168		186,849	
Ontario	16,259,718		12,186,799	
Saskatchewan	86,808,251		85,912,327	
Alberta	2,363,292,190		2,760,200,947	
British Columbia	357,137,966		442,510,550	
Northwest and Yukon territories	2,130,134		15,508,438	
Total, Canada	2,825,903,541		3,316,603,024	
Waste and flared				
Saskatchewan	15,642,659		17,393,977	
Alberta	59,975,782		57,965,921	
British Columbia	8,713,656		6,017,779	
Northwest and Yukon territories	963,444		945,732	
Total, Canada	85,295,541		82,323,409	
Reinjected				
Saskatchewan	–		–	
Alberta	236,068,920		4,308,300	
British Columbia	5,515,480		4,308,300	
Total, Canada	241,584,400		321,232,437	
Net withdrawals				
New Brunswick	105,114	90,547	97,114	83,654
Quebec	170,168	25,525	186,849	27,841
Ontario	16,259,718	6,333,160	12,186,799	4,874,720
Saskatchewan	71,165,592	8,951,676	68,518,350	8,640,164
Alberta	2,067,247,488	290,671,829	2,385,310,889	329,888,496
British Columbia	342,908,830	36,268,945	432,184,471	43,434,539
Northwest and Yukon territories	1,166,690	207,209	14,562,706	1,550,928
Total, Canada	2,499,023,600	342,548,891	2,913,047,178	388,500,342
Processing shrinkage				
Saskatchewan	2,200,447		3,440,934	
Alberta	287,838,300		393,383,198	
British Columbia	15,170,203		41,583,189	
Total, Canada	305,208,950		438,407,321	
Net new supply, Canada	2,193,814,650		2,474,639,857	

Sources: Statistics Canada, and provincial government reports.
^p Preliminary; – Nil. [1] 14.73 psia.

Northwest Territories and the Yukon. On the northern frontier, industry activity centred on the Mackenzie Delta and the Arctic islands, the sites of significant discoveries in recent years. In the Mackenzie Delta, much of the drilling activity early in the year was focussed on the west side of Richards Island around the IOE Taglu G-33 gas discovery well which had been completed late in 1971. Imperial Oil Limited drilled tests within a radius of 2 to 8 miles of the well, resulting in three further gas discoveries to the west, southwest and northeast. Another well, IMP Ivik J-26, located 21 miles northwest of Taglu is classified as an oil discovery, although some gas was reported in tests. Forty-five miles southwest of Taglu, a gas and condensate discovery was indicated by the Gulf Mobil Parsons F-09 well. Further drilling was planned in the area during the 1972-73 winter drilling season and potential discoveries were indicated from three wells which were drilling at year-end. Gas flows were encountered on tests of three separate zones at Gulf Mobil Ya Ya P-53, slightly east and 10 miles south of Taglu. Indications of gas were also reported from Shell Niglintgak H-30, 12 miles southwest of Taglu, and Gulf Imp Shell Titalik K-26, 20 miles south and slightly west of Taglu.

During 1972 two major agreements were announced which will help to finance the very expensive operations in the Delta area. The first was in March when Imperial Oil Limited announced an agreement with two United States firms, Michigan-Wisconsin Pipe Line Company of Detroit and Natural Gas Pipeline of America, Chicago, under which the firms will provide funds to encourage development and production of natural gas reserves on Imperial's Mackenzie Delta acreage. In return the two U.S. companies were given a commitment on any gas reserves developed up to a maximum of 10 trillion cubic feet. Under the terms of the agreement the companies will advance $10 million per year for four years starting in 1972. In addition the companies will make interest-free prepayments of 2 cents per Mcf of gas reserves committed, subject to conditions related to such factors as regulatory approval for exports, approval of pipeline construction and the conditions of repayment. An important aspect of the contract is that it established a minimum initial price of 32 cents per Mcf of gas, with provisions for a minimum increase of 2 cents per Mcf in 2 years and price determination every five years thereafter with minimum increases of 5 cents per Mcf. Under certain conditions, the price could be increased above the minimum. The amount of gas reserves discovered to date in the Delta area had not been revealed by year-end. However, Imperial Oil considers that a minimum reserve of 15 trillion cubic feet is needed to

Table 4. Canada, production, trade and total sales of natural gas, 1962-72

		Net Withdrawals	Imports	Exports	Sales in Canada
1962	Mcf	894,671,614	5,575,466	319,565,908	412,061,509
	$	104,060,533	1,801,912	72,423,312	257,589,445
1963	Mcf	993,388,491	6,877,438	340,953,146	451,598,298
	$	124,458,230	2,356,310	75,630,344	287,584,177
1964	Mcf	1,327,664,338	8,046,365	404,143,095	504,503,380
	$	145,057,536	2,871,145	97,608,555	327,982,720
1965	Mcf	1,442,448,070	15,673,069	403,908,528	573,016,494
	$	158,938,464	5,809,335	104,279,744	369,307,232
1966	Mcf	1,341,833,195	43,550,818	426,223,806	635,514,622
	$	179,183,990	17,592,370	108,749,931	416,212,202
1967	Mcf	1,471,724,535	52,871,671	505,164,622	698,223,437
	$	197,983,450	19,914,301	123,663,828	454,722,005
1968	Mcf	1,692,300,787	88,227,825	598,143,763	765,786,814
	$	225,263,658	35,392,758	153,751,558	490,767,434
1969	Mcf	1,977,838,205	37,732,703	669,815,767	843,164,967
	$	262,332,030	16,025,449	176,187,766	537,186,938
1970	Mcf	2,277,108,791	11,877,827	768,112,547	917,440,879
	$	315,099,792	5,123,896	205,988,180	582,316,948
1971	Mcf	2,499,023,600	16,010,217	903,051,071	1,001,328,624
	$	342,548,891	7,021,000	250,719,000	641,898,026
1972^p	Mcf	2,913,047,178	15,759,538	1,007,053,829	1,145,797,145
	$	388,500,342	7,629,000	306,843,000	740,382,930

Source: Statistics Canada. Figures in Tables 4 and 12 differ for imports and exports because of different reporting procedures and timing.
^{p} Preliminary.

Table 5. Canada, liquids and sulphur recovered from natural gas, 1962-72

	Propane	Butane	Condensate/ Pentanes Plus	Sulphur
	(bbl)	(bbl)	(bbl)	(lt)
1962	3,618,158	2,745,903	17,593,152	1,035,988
1963	4,203,558	3,242,280	21,740,013	1,281,999
1964	6,515,222	5,529,455	25,264,469	1,472,583
1965	10,168,610	6,927,505	27,867,535	1,589,586
1966	12,473,645	8,177,144	29,365,322	1,729,455
1967	14,146,829	9,327,710	30,741,400	2,168,646
1968	15,855,467	10,421,958	33,202,168	3,042,105
1969	17,807,022	11,184,685	38,534,025	3,714,312
1970	21,274,353	13,203,744	44,151,409	4,240,982
1971	24,225,504	15,447,329	46,898,136	4,555,290
1972^p	30,431,098	19,766,066	60,674,498	6,617,216

Sources: Statistics Canada and provincial government reports.
^{p} Preliminary.

justify a large-diameter pipeline from the area.

The second agreement was announced in December, when Gulf Oil Canada Limited revealed a financing agreement with Alberta and Southern Gas Co. Ltd. of Calgary and Pacific Lighting Gas Development Co. of Los Angeles. Under this agreement, the two gas companies will make interest-free loans up to $60 million over five years to be used for Gulf's exploration and development programs in the Delta. The companies will then be able to purchase up to 4 trillion cubic feet of Gulf's share of natural gas reserves developed on its acreage, and Gulf will have the option to sell them an additional 2 trillion cubic feet of gas. Additional loans may be made at a later stage if and when export and project approvals are obtained. The initial contract price for the gas will be based on the best area price at the time, and it will be renegotiated at two-year intervals.

In the Arctic islands, exploration continued unabated and significant discoveries were made. On the Sabine Peninsula of Melville Island, Panarctic Oils Ltd. drilled two successful wells in a program to delineate the limits of the reservoir encountered at the Drake Point discovery well in 1969. The first well was located 5 miles to the southeast, while the second well extended the known limits to the seacoast 12 miles southeast of the discovery. These discoveries indicate a field of major proportions. Later in the year, Panarctic made another gas discovery 30 miles west of Drake Point on the west coast of the peninsula. The new well, Panarctic Tenneco et al POR Hecla F-62, apparently encountered significant gas shows at about 3,000 feet. Drilling was started late in 1972 at a new well, Dome Arctic Ventures Wallis K-62, on King Christian Island northeast of Melville Island. Early in 1973, the well was reported to have encountered over 300 feet of net pay which indicated high gas deliverability on testing, making the well a significant new discovery. This new well is approximately 20 miles northwest of Panarctic's 1970 King Christian discovery which is also classified as a major gas well. No estimate has been made of the total gas reserves found to date in the Arctic islands, but industry sources have estimated that about 35 trillion cubic feet would be required to justify a major transmission line south to continental markets.

On the mainland other wells were drilled south of the Mackenzie Delta area in the Northwest Territories and the Yukon but no discoveries were reported. The total number of wells drilled in the Territories, which includes the Arctic islands, declined to 71 in 1972 from 76 in 1971, but total footage increased. Land under federal permits and leases decreased to 445.1 million acres at the end of 1972 from 469.2 million acres in 1971.

Saskatchewan. In Saskatchewan in 1972 the number of wells and footage drilled were essentially the same as in 1971. However, successful exploratory gas well completions rose to 47 in 1972 from 34 in 1971, whereas development gas well completions dropped to 39 in 1972 from 74 in 1971. All the gas wells were drilled in the western areas of the province where all of Saskatchewan's gas fields are located. Much of the drilling activity was in or near the Hatton field in the southwestern corner of the province. At the end of 1972 there were 439 gas wells in operation, out of 714 capable of production.

Eastern Canada. Additional gas discoveries were made in 1972 at Sable Island, 190 miles east-southeast of Halifax, Nova Scotia, following the significant oil and gas discovery well which was drilled near the west end of the island in 1971. Drilling one mile east of the 1971 discovery resulted in a successful gas well. Two additional tests, both successful gas wells, were drilled west of the 1971 discovery well utilizing a special

Table 6. Wells drilled by province, 1971-72

	Oil		Gas		Dry[1]		Total	
	1971	1972^p	1971	1972^p	1971	1972^p	1971	1972^p
Western Canada								
Alberta	361	514	691	1,010	962	1,195	2,014	2,719
Saskatchewan	266	316	108	86	261	232	635	634
British Columbia	46	37	36	61	112	119	194	217
Manitoba	2	–	–	–	13	6	15	6
Yukon and Northwest territories	1	1	3	7	72	63	76	71
Westcoast offshore	–	–	–	–	–	–	–	–
Hudson Bay offshore	–	–	–	–	–	–	–	–
Subtotal	676	868	838	1,164	1,420	1,615	2,934	3,647
Eastern Canada								
Ontario	2	4	47	34	83	97	132	135
Quebec	–	–	–	–	5	7	5	7
Atlantic provinces	–	–	–	–	1	2	1	2
Eastcoast offshore	–	–	1	2	18	16	19	18
Subtotal	2	4	48	36	107	122	157	162
Total, Canada	678	872	886	1,200	1,527	1,737	3,091	3,809

Source: Canadian Petroleum Association.
[1] Includes suspended wells and abandoned wells. ^{p} Preliminary; – Nil.

drilling platform, constructed on the edge of the island, from which the wells were directionally drilled beneath the ocean. In August another gas discovery was reported offshore at Mobil Tetco Thebaud P-84, located 6 miles southwest of the 1971 discovery. Tests of five zones in the well recovered gas at flows of up to 21 MMcf/d and in three of these zones condensate was recovered at rates of up to 120 b/d. Shell Canada Limited continued its offshore drilling program and reported noncommercial gas shows at the Shell Primrose N-50 well, located 30 miles east of Sable Island. More than 30 wells had been drilled off the Nova Scotia coast, including Sable Island, by the end of 1972 and drilling is continuing.

In the Grand Banks region southeast of Newfoundland, some 375 miles east of Sable Island, Amoco Canada Petroleum Company Ltd. and Imperial Oil Enterprises Ltd. continued their exploratory program using two semisubmersible rigs to complete eight wells during 1972. Noncommercial hydrocarbon shows were reported at the Amoco IOE Heron well, 280 miles south of St. John's, Newfoundland, and at the Amoco IOE Cormorant A-93 well, 220 miles southeast of St. John's. Late in 1972, drilling was started at the Mobil Adolphus K-41 well, approximately 75 miles northeast of the Cormorant A-93 location, using the Sedco J semisubmersible drilling unit which had been completed in the shipyards at Halifax in September. Since 1966, 17 wells have been drilled in the Grand Banks area, including the three under way at year-end. No drilling was attempted in any other east coast offshore area during 1972. Offshore acreage under federal permits declined in 1972 to 292.0 million acres, compared with 318.5 million acres at the end of 1971.

In Ontario, total footage drilled was down from the 1971 level because of a sharp drop in development drilling which offset increased exploratory drilling. In the gas producing region of southwestern Ontario, seven gas discoveries and 27 successful development gas wells were completed compared to ten gas discoveries and 37 development wells completed in 1971. Exploration also continued in the prospective sedimentary basins in the Hudson Bay-James Bay area. Although companies again reduced their acreage held under federal permits in Hudson Bay and Hudson Strait, from 85.7 million acres in 1971 to 40.6 million acres at the end of 1972, further offshore drilling in Hudson Bay is expected.

Seven exploratory wells were completed in Quebec, compared to five in 1971. Although a small gas show was reported from the Shell Ste. Francoise Romaine #1 well, 40 miles southwest of Quebec City, no discoveries were reported. Two wells were drilled and abandoned on Prince Edward Island.

Reserves

Proved remaining marketable reserves of natural gas in Canada declined in 1972, the first recorded decline

Table 7. Footage drilled in Canada for oil and gas by province, 1971-72

	Exploratory		Development		All Wells	
	1971	1972P	1971	1972P	1971	1972P
Alberta	4,287,658	5,122,265	3,692,853	4,929,202	7,980,511	10,051,467
Saskatchewan	815,762	732,410	999,276	1,083,027	1,815,038	1,815,437
British Columbia	518,807	700,963	462,084	441,987	980,891	1,142,950
Manitoba	15,881	16,890	26,858	–	42,739	16,890
Territories and Arctic islands	469,287	568,715	–	5,387	469,287	574,102
Westcoast offshore	–	–	–	–	–	–
Hudson Bay offshore	–	–	–	–	–	–
Total, western Canada	6,107,395	7,141,243	5,181,071	6,459,603	11,288,466	13,600,846
Ontario	128,598	154,170	119,846	77,852	248,444	232,022
Quebec	28,555	59,915	–	–	28,555	59,915
Atlantic provinces	4,416	25,000	–	–	4,416	25,000
Eastcoast offshore	204,366	191,210	–	–	204,366	191,210
Total, eastern Canada	365,935	430,295	119,846	77,852	485,781	508,147
Total, Canada	6,473,330	7,571,538	5,300,917	6,537,455	11,774,247	14,108,993

Source: Canadian Petroleum Association.
P Preliminary; – Nil.

since the Canadian Petroleum Association began compiling estimates in the early 1950's. Proved reserves at the end of 1972 amounted to 52,935,782 MMcf, down 2,526,068 MMcf, or 4.6 per cent, from the level at the end of 1971. The decline resulted from the combined effects of a substantial downward revision of the reserves in existing pools together with relatively low additions from new discoveries and record high production levels. Revisions to existing pools decreased reserves by 2,404,125 MMcf. The CPA set the amount of gas produced from these reserves at 2,247,798 MMcf and showed that underground storage of gas was decreased by 5,580 MMcf. On the positive side, a total of 1,634,897 MMcf of gas was added by extension to existing pools while new discoveries added 487,538 MMcf. The estimates of gas reserves do not include any allowance for the discoveries in the Mackenzie Delta or the Arctic islands because much of the well data is confidential and it will be some time before pipelines will be extended to this area.

Table 8. Canada, estimated year-end marketable reserves of natural gas, 1971-72

	1971	1972
	(millions of cubic feet)	
Alberta	43,415,155	41,377,769
British Columbia	9,614,625	9,145,563
Saskatchewan	812,727	825,270
Eastern Canada	273,045	250,382
Northwest Territories	1,346,298	1,336,798
Total	55,461,850	52,935,782

Source: Canadian Petroleum Association.

Natural gas processing

The addition of new processing facilities in 1972 approached the record level of the previous year as three large new plants were placed on stream and some major expansions were completed. New capacity put on stream in 1972 amounted to 2,424 MMcf/d, and raised the total input capacity for all Canadian plants to 15,417 MMcf/d. The potential natural gas liquid production available from the industry with facilities existing at the end of 1972, was 106,411 b/d of propane, 50,890 b/d of butane and 233,953 b/d of pentanes plus. In addition, the plants had the capacity to produce 10,427 MMcf/d of residue sales gas and 25,435 lt/d of sulphur. Additional volumes of residue gas and natural gas liquids were recovered but are being reinjected as part of conservation schemes and therefore are not available for consumption at present.

One of the major new plants put on stream early in 1972 was the Chevron Standard Limited plant in the Kaybob field in Alberta. This plant, one of the largest

Table 9. Canada, natural gas processing plant capacities by fields, 1972

Main Gas Field Served	Raw Gas Capacity	Residue Gas Produced
	(million cf/day)	
Alberta		
Acheson	6	5
Alderson	24	24
Atlee, Buffalo	31	30
Alexander, Calahoo	36	35
Bassano	2	2
Bigoray	13	12
Bigstone	48	36
Black Butte	10	10
Bonnie Glen	48	40
Boundary Lake South	25	22
Brazeau River	104	96
Brazeau South	66	60
Burnt Timber	54	45
Calling Lake	15	15
Carbon	155	150
Caroline (2 plants)	53	45
Carson Creek	100	48
Carstairs	334	280
Cessford (4 plants)	190	184
Cessford North (2 plants)	21	20
Chigwell (2 plants)	12	10
Connorsville, Cessford	5	5
Countess (3 plants)	42	40
Crossfield (2 plants)	319	218
Dunvegan	207	160
East Crossfield	146	87
East Rainbow Lake	18	11
Edson	377	339
Enchant	5	5
Equity, Ghost Pine	16	15
Ferrier (2 plants)	110	94
Ferrier South	20	19
Ferrybank	20	19
Figure Lake	12	12
Flat Lake	25	25
Ghost Pine	113	111
Gilby (6 plants)	136	119
Gilby North	19	18
Gold Creek	60	40
Golden Spike	45	reinj
Greencourt	30	28
Harmattan-Elkton (2 plants)	486	15
Harmattan-Elkton South	5	4
Hatton	8	7
Homeglen-Rimbey	423	357
Hussar	120	110
Innisfail	15	10
Joffre	8	5
Judy Creek, Swan Hills (2 plants)	210	142
Jumping Pound	250	200
Kaybob	95	92
Kaybob South (3 plants)	827	341
Kessler	6	5
Keystone	8	7
Lac la Biche	25	25
Leduc Woodbend	35	31
Lone Pine Creek	67	54
Mannville	33	32
Marten Hills	133	130
Marten Hills South	24	24
Mikwan North	15	13
Minnehik-Buck Lake	108	100
Mitsue	21	15
Morinville, St. Albert-Big Lake	22	20
Nevis, Stettler (2 plants)	216	178
Okotoks	30	13
Olds	100	76
Oyen	3	3
Paddle River	30	28
Parflesh	2	2
Phoenix	3	2
Pembina (12 plants)	158	136
Pincher Creek	105	75
Prevo	5	4
Princess (2 plants)	15	15
Provost (4 plants)	127	120
Quirk Creek	90	68
Rainbow Lake	81	reinj
Rainier	3	3
Redwater	22	8
Redlaw	7	7
Savanna Creek	75	63
Sedalia	5	5
Sibbald	6	5
Simonette	15	11
South Lone Pine Creek	35	26
Strachan D-3	275	214
Strachan, Ricinus West	400	242
Strathmore	2	2
Sturgeon Lake South	12	9
Swalwell	4	4
Sylvan Lake (2 plants)	91	82
Three Hills Creek	10	9
Turner Valley	40	25
Ukalta	6	6
Verger	6	5
Virginia Hills	12	10
Vulcan	25	22
Warwick	9	9
Waskahigan	16	14
Waterton	468	311
Wayne-Rosedale	65	62
Wildcat-Hills	112	95

Table 9 (concl'd)

Main Fields Served	Raw Gas Capacity	Residue Gas Produced
	(million cf/day)	
Willesden Green	17	15
Wilson Creek	23	19
Wimborne	60	46
Windfall, Pine Creek	215	132
Wintering Hills	20	20
Wood River	5	5
Worsley	23	21
Pipeline at Ellerslie[1]	70	66
Pipeline at Empress[2] (2 plants)	3,000	2,892
Pipeline at Cochrane[3]	1,000	970
Saskatchewan		
Cantuar	25	24
Coleville, Smiley	52	51
Dollard	2	2
Milton	4	4
Smiley	4	3
Steelman	38	30
Totnes	7	7
West Gull Lake	15	14
British Columbia		
Beaver River	240	240
Boundary Lake (2 plants)	29	27
Clarke Lake	1,300	1,090
Fort St. John	500	440
Ontario		
Becher	1	1
Corunna (2 plants)	5	5
Port Alma	16	16
Northwest Territories		
Pointed Mountain	189	189

Source: Natural Gas Processing Plants in Canada (*Operators List 7*) January 1973, Department of Energy, Mines and Resources.
1 Plant reprocesses gas owned by Northwestern Utilities, Limited. 2 Plant reprocesses gas owned by TransCanada PipeLines Limited. 3 Plant reprocesses gas owned by exporting companies.

in Canada, has a raw gas capacity of 445 MMcf/d and capacity to produce 33,840 b/d of pentanes plus and 3,065 lt/d of sulphur. Residue gas capability is 284 MMcf/d, of which 230 MMcf/d is reinjected and 54 MMcf/d is sold as pipeline gas. Another large new plant was completed by Aquitaine Company of Canada Ltd. at Ram River to process gas from the Ricinus West and Strachan pools. It has a raw gas capacity of 410 MMcf/d, residue gas capacity of 242 MMcf/d and can produce 3,510 b/d of pentanes plus in addition to 4,110 lt/d of sulphur. The third major plant was constructed by Anderson Exploration Ltd. in the Dunvegan field in northwestern Alberta. The plant can process 207 MMcf/d of raw gas to produce 160 MMcf/d of residue gas and 1,600 b/d of pentanes plus. Processing capability was also increased significantly by the expansion of the Canadian Superior Oil Ltd. recycling plant at Harmattan from 246 MMcf/d to 444 MMcf/d. Smaller plants were also completed in Alberta at Gilby, Huxley, Verger, Bigoray, Joffre, Corbett Creek, Countess, Ferrybank, Hussar and Mannville. Plant expansions were undertaken at Strachan, North Nevis and Lone Pine Creek.

In northeastern British Columbia, Westcoast Transmission Company Limited completed the expansion of its Fort Nelson plant, thereby substantially increasing gas processing capacity in this area. Rated raw gas treating capacity of the plant at year-end was 1,300 MMcf/d and residue gas capacity was 1,090 MMcf/d. Part of the raw gas supply for the Fort Nelson plant will come from the Pointed Mountain field in the Northwest Territories. Amoco Canada Petroleum Company Ltd. has constructed a new 189 MMcf/d plant at Pointed Mountain to dehydrate the gas before it is shipped through the Westcoast system to Fort Nelson.

Transportation

A total of 2,800 miles of pipeline was added to transmission, distribution and gathering systems in Canada in 1972. TransCanada PipeLines Limited continued its major expansion program, begun in 1971, to significantly increase the capability of its system to transport gas eastward from the producing regions of Alberta. In Manitoba and Saskatchewan, 227 miles of 42-inch pipeline were laid as part of TransCanada's fourth line between the Alberta border and Winnipeg. The company also laid 652 miles of 36-inch pipe in eastern Manitoba and at various locations across northern Ontario as construction proceeded on a second line from Winnipeg to the Toronto area. Thirty-three miles of 24-inch diameter line were laid as part of a second line under construction between Toronto and Montreal. Because of a delay in provincial approvals to remove additional gas from Alberta, the extent of the company's 1973 program was uncertain at year-end but previous plans called for an additional 149 miles of 42-inch pipeline in Saskatchewan and Ontario, 348 miles of 36-inch pipeline east of Winnipeg in Manitoba and northern Ontario, and 37 miles of 24-inch line between Montreal and Toronto.

In British Columbia, the Westcoast Transmission Company Limited system was also expanded. The main pipeline, which in 1971 extended from the Beaver River field on the Yukon - British Columbia border to Sumas on the southern border of the province, was extended northward by the construction of 34 miles of 20-inch pipeline to tie in the Pointed Mountain field in the Northwest Territories. In addition, the company constructed 87 miles of 36-inch pipeline in a number of locations to loop the main pipeline.

In Alberta, The Alberta Gas Trunk Line Company Limited transports all export gas from the producing fields to provincial boundaries where it is delivered to the large transmission companies such as TransCanada PipeLines. Major expansions outside the province, such as that of the TransCanada system, have therefore generated demands for greater capacity in the Alberta Gas Trunk system. To meet increased demand the company installed 537 miles of new pipeline in sizes up to 42-inch diameter to increase capacity of main transmission lines and to tie in new producing areas. Producers in the fields, in turn, developed additional gathering capacity in new and existing fields to provide gas for the Alberta Gas Trunk system.

In the six provinces served by natural gas, distribution companies expanded service to many new customers. In Quebec, the eastern limits of the area served by western Canadian gas were extended when Gaz Métropolitain, inc. constructed 27 miles of 16-inch line to provide service to the Sidbec steel mill at Contrecoeur.

Before 1972, each of three groups of companies were separately investigating the feasibility of building a major natural gas transmission line from the Canadian Arctic to southern markets in Canada and the United States. In 1972, Gas Arctic Systems Study Group and the Northwest Project Study Group decided to amalgamate their efforts and formed a new company, Canadian Arctic Gas Study Limited, to carry out joint studies. The third group which has been investigating a northern pipeline is Mountain Pacific Pipeline Ltd. The Canadian Arctic Gas group is studying the feasibility of a 3,000-mile, 48-inch pipeline which would deliver more than 4 billion cubic feet of gas daily and would cost around $5 billion. Although it was originally anticipated that much of the gas in the line would come from the Prudhoe Bay area on the Alaska north slope, the successful exploration in the Mackenzie Delta has now increased the importance of Canadian production to the early viability of the pipeline. The 25 member companies of Canadian Arctic Gas have spent about $25 million in economic, engineering and environmental studies related to the proposed line. The companies expect to make an application in late summer 1973 to build and operate the pipeline. If regulatory approvals are received by 1975, first shipments could be made by 1979 and operation at full capacity could be achieved in the following two years.

The succession of major gas discoveries in the Arctic islands generated the need for studies of the problems and prospects of a major transmission line from this area. The problems associated with such a pipeline are formidable since it would be necessary to 'island-hop' to the mainland, crossing several straits. In mid-1972, Panarctic Oils Ltd. initiated a study of the environmental impact of a pipeline extending from the Arctic to southern Canada following a route either to the east or to the west of Hudson Bay. Early in 1973, Panarctic Oils Ltd., TransCanada PipeLines Limited, Canadian Pacific Investments Limited and Tenneco Oil & Minerals, Ltd. formed the Polar Gas Project to expand on the initial route surveys and carry out a broader program of research and planning related to a pipeline to the eastern Arctic.

To assist companies in the preliminary planning stages, the federal government had issued some general guidelines for the construction and operation of northern pipelines in August 1970. In June 1972 expanded guidelines were issued to allow for more detailed planning. The new guidelines provide more detail on the type of documented environmental research which will be required to obtain approval of a pipeline. In addition, responsibilities to the indigenous population which will be expected of companies operating in the North were enlarged upon. Further elaboration was given on the concept of a transportation corridor from the North, which will initially accommodate one oil and one gas pipeline, to minimize environmental and social disturbance and ensure maximum benefits to northern residents and consumers.

Markets and trade

Sales of gas to Canadian customers rose by 14.4 per cent in 1972 to 3,139 MMcf/d, a substantial increase over the 9.1 per cent growth which occurred in 1971. Exports to the United States rose by 10.7 per cent to 2,766 MMcf/d. The rise in exports was less than the 16.8 per cent increase in 1971, but this was expected since the National Energy Board has not authorized any export increases since 1970. The last increase authorized in 1970 was put into effect in November 1972 by Westcoast Transmission Company Limited. Imports from the United States, mainly into Ontario, averaged 40 MMcf/d, essentially the same as in 1971.

Industrial sales accounted for slightly more than half of all sales in Canada in 1972. Sales in this category rose to 1,708 MMcf/d, an increase of 14.7 per cent over the previous year. Commercial sales also showed a substantial growth, rising 16.8 per cent to average 662 MMcf/d or 21 per cent of total Canadian sales. Residential sales increased by 12 per cent to 769 MMcf/d. Total revenue from all sales in Canada amounted to $741 million, made up of $278 million from industrial sales, $176 million from commercial sales and $287 million from residential sales.

Table 10. Gas pipeline mileage in Canada, 1968-72

	1968	1969	1970	1971	1972[e]
			(miles)		
Gathering					
New Brunswick	6	6	6	6	6
Quebec	1	1	1	1	1
Ontario	1,142	1,193	1,121	1,092	1,092
Saskatchewan	794	805	893	875	901
Alberta	3,350	3,663	4,049	4,243	4,588
British Columbia	611	650	718	948	948
Northwest Territories and Yukon	–	–	2	4	11
Total	5,904	6,318	6,790	7,169	7,547
Transmission					
New Brunswick	13	13	13	13	13
Quebec	148	148	148	148	175
Ontario	3,518	3,612	3,612	3,711	4,177
Manitoba	1,146	1,227	1,321	1,445	1,470
Saskatchewan	4,332	4,504	4,990	5,361	5,500
Alberta	5,620	6,054	6,782	7,206	7,700
British Columbia	1,758	2,371	2,372	2,653	2,740
Total	16,535	17,929	19,238	20,537	21,775
Distribution					
New Brunswick	32	32	32	32	32
Quebec	1,487	1,572	1,568	1,638	1,730
Ontario	14,497	15,058	15,610	16,080	16,500
Manitoba	1,522	1,466	1,513	1,630	1,700
Saskatchewan	2,031	2,126	2,236	2,355	2,546
Alberta	5,781	6,721	7,553	7,841	8,183
British Columbia	4,610	5,004	5,197	5,203	5,270
Total	29,960	31,979	33,709	34,779	35,961
Total, Canada	52,399	56,226	59,737	62,485	65,283

Source: Statistics Canada. [e] Estimated by Mineral Resources Branch.

Ontario accounted for almost two thirds of the increase in Canadian consumption in 1972 and a 23 per cent rise in industrial sales was the major factor in raising provincial consumption by 20.3 per cent to 1,514 MMcf/d. Ontario now takes 48.2 per cent of the total gas marketed in Canada. Alberta is the second largest consuming province and it accounted for 23.5 per cent of all gas marketed in Canada in 1972. Sales in Alberta rose by 8.2 per cent to 736.4 MMcf/d. British Columbia markets also consumed substantially more gas, averaging 324 MMcf/d, for an increase of 17.2 per cent. Sales of natural gas in Saskatchewan, Manitoba and Quebec increased by from 5 to 9 per cent while sales in the small New Brunswick market dropped. The remaining three provinces do not have natural gas services.

Attention during 1972 focused on the question of the fair wellhead value of natural gas as a result of a study carried out by the Alberta Energy Resources Conservation Board (AERCB). Wellhead prices followed an upward trend in recent years because of the increasing competition for available reserves by both domestic and export-oriented companies. However, the National Energy Board ruled in late 1971 that no surplus gas was available in Canada for export and it was contended in the producing sector that the earlier competition was thereby reduced. To determine if current practices were in Alberta's interest, the Alberta government ordered the AERCB to undertake an enquiry into the field of pricing of natural gas, with reference to questions such as the factors which control the field price of natural gas, the suitability of current pricing provisions for natural gas marketed outside the province, the present and anticipated field prices of natural gas, and alternatives to current pricing practices which would enhance the benefits to residents of Alberta. Following public hearings the AERCB presented findings and recommendations to the government in August. One of the major findings was that the demand for gas for export to the United States was a major element in maintaining competition for Alberta gas reserves, and the AERCB recommended steps which should be taken to maintain and strengthen competition in the province. With respect to contracts, the AERCB found that many existing contracts had provisions for price escalation and contract redetermination, but it recommended a generally higher rate of escalation, around 3 to 4 per cent per year, together with price redetermination at least every five years. The 1972 average field price for all contracts was estimated to be 16 cents/Mcf, which the AERCB considered to be 10 cents less than the true field value of the gas.

In November, the Alberta government revealed new natural gas policies, based on the AERCB study, which emphasize the pricing aspects of gas being removed from the province. Producers and buyers were encouraged to review and amend existing contracts to comply generally with the AERCB recommendations including price redetermination provisions every two years. Under the new policy, the AERCB will require all purchasers of gas for extraprovincial markets to file with the Board details of pricing provisions of any new contracts and all amendments to existing contracts. Beginning in April 1973 the AERCB will report annually to the government on how new or existing contracts are meeting the new pricing provisions. At the same time, the Alberta government outlined its intention to protect gas consumers in the province from higher wellhead prices, probably through some form of rebate to cover increased gas costs above those normally expected due to rising costs and inflation. The government also proposed a new 5-year plan to extend gas to an estimated 15 per cent of the households in the province without service, which are located mostly in rural areas.

During 1972 contract renegotiations were under way between gas producers and buyers in Alberta, in some cases prior to the announcement of the new gas policy. For example, Petrofina Canada Ltd. renegotiated its existing contract with Alberta and Southern Gas Co. Ltd. which buys gas for export to the California market area. Under the new contract, the average price for gas was set at 23.5 cents/Mcf on July 1, 1972, up 6.25 cents/Mcf from the 17.25 cents/Mcf under the old contract, and a further increase of 3 cents/Mcf will become effective July 1, 1973. Another amendment reduced the renegotiation interval from 5 to 2 years; therefore, the next price redetermination will be effective July 1, 1974. Other companies were known to be renegotiating contracts but pricing details had not been released at year-end.

The Alberta government had not approved any further applications for gas export from the province since the review of natural gas policies began in early 1972, although in December 1971 the AERCB had recommended that TransCanada PipeLines be authorized to remove an additional .4 trillion cubic feet from the province. TransCanada also applied for

Table 11. Canada, sales of natural gas by province, 1972*p*

	Mcf	$	Average $/Mcf	Number of Customers, Dec. 31/72
New Brunswick	58,438	183,735	3.14	1,100
Quebec	58,198,054	57,269,187	0.98	198,440
Ontario	552,649,797	420,569,059	0.76	898,662
Manitoba	59,803,714	39,064,003	0.65	142,600
Saskatchewan	88,017,634	43,153,945	0.49	158,371
Alberta	268,767,598	89,089,436	0.33	353,274
British Columbia	118,301,910	91,053,565	0.77	286,648
Total, Canada	1,145,797,145	740,382,930	0.65	2,039,095
Previous totals				
1968	765,786,814	490,767,434	0.64	1,767,010
1969	843,164,967	537,186,938	0.64	1,836,303
1970	917,440,879	582,316,948	0.63	1,889,808
1971	1,001,328,624	641,898,026	0.64	1,958,083

Source: Statistics Canada. *p* Preliminary.

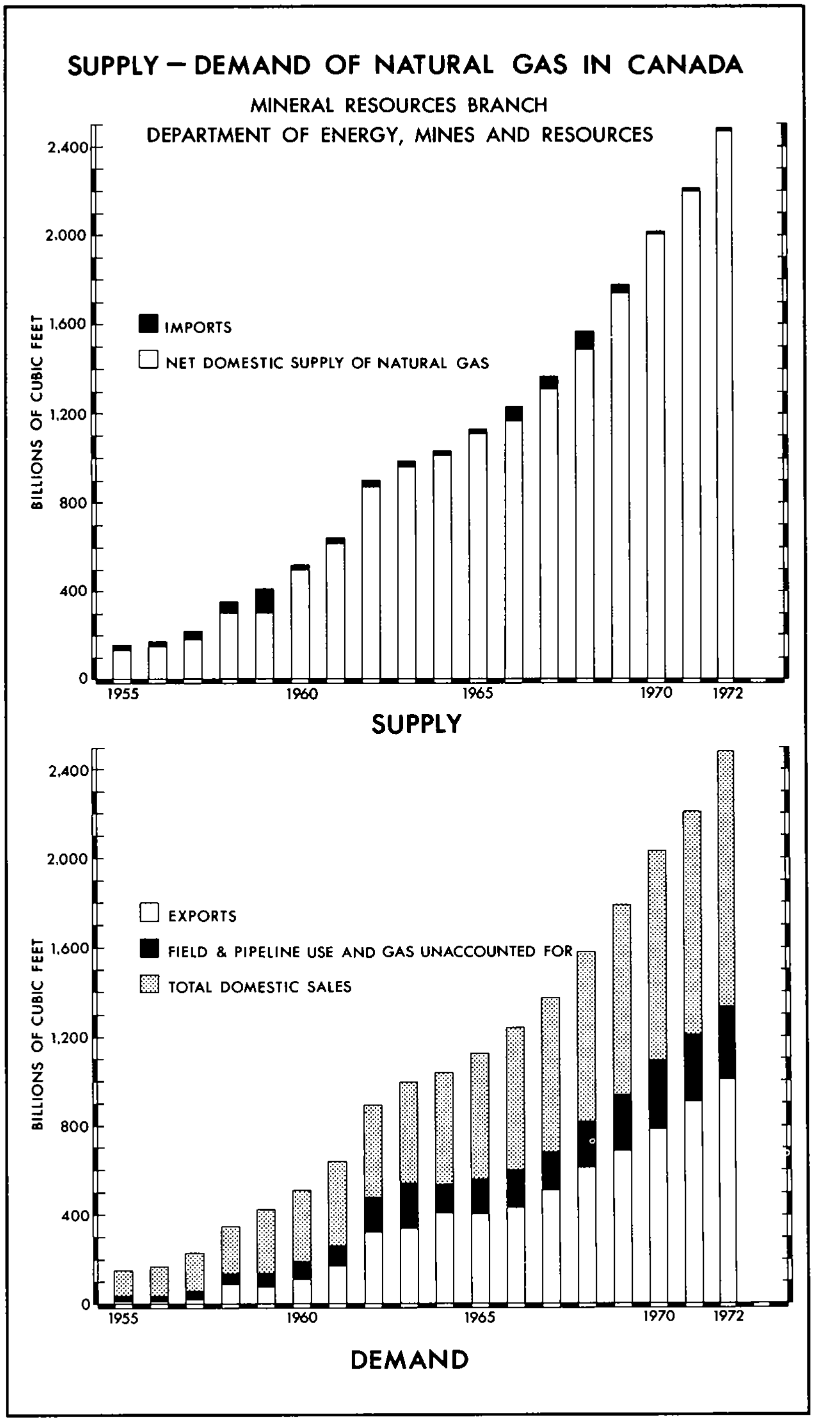

SUPPLY — DEMAND OF NATURAL GAS IN CANADA
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
BILLIONS OF CUBIC FEET
2,400
2,000
1,600
1,200
800
400
0
IMPORTS
NET DOMESTIC SUPPLY OF NATURAL GAS
1955
1960
1965
1970
1972
SUPPLY
BILLIONS OF CUBIC FEET
2,400
2,000
1,600
1,200
800
400
0
EXPORTS
FIELD & PIPELINE USE AND GAS UNACCOUNTED FOR
TOTAL DOMESTIC SALES
1955
1960
1965
1970
1972
DEMAND

Table 12. Canada, supply and demand of natural gas

	1971		1972^{p}	
	(MMcf)	(MMcf)	(MMcf)	(MMcf)
Supply				
Gross new production		2,825,904		3,316,603
Field waste and flared		-85,296		-82,323
Reinjected		-241,584		-321,233
Net withdrawals		2,499,024		2,913,047
Processing shrinkage		-305,209		-438,407
Net new supply		2,193,815		2,474,640
Removed from storage	97,363		99,302	
Placed in storage	-93,485		-104,284	
Net storage		+3,878		-4,982
Total net domestic supply		2,197,693		2,469,658
Imports		14,349		15,693
Total supply		2,212,042		2,485,351
Demand				
Exports		912,224		1,009,651
Domestic sales				
Residential	250,796		280,811	
Industrial	543,612		623,405	
Commercial	206,920		241,581	
Total		1,001,328		1,145,797
Field and pipeline use				
In production	164,935		189,605	
Pipeline	120,159		127,799	
Other	13,514		24,586	
Line pack changes	853		3,655	
Total field and pipeline use		299,461		345,645
Gas unaccounted for		-971		-15,742
Total demand		2,212,042		2,485,351
Total domestic demand		1,299,818		1,475,700
Average daily demand		3,561		4,043

Source: Statistics Canada and provincial government reports.
^{p} Preliminary.

export permits on an additional 2.59 trillion cubic feet in October 1972 but the AERCB decision on this request was pending at year-end.

A new export scheme to meet short-term requirements was introduced in August 1972 with the formation of Pan-Alberta Gas Ltd., currently a wholly owned subsidiary of The Alberta Gas Trunk Line Company Limited. The objective of the company is to contract for excess gas production capability in Alberta and resell the gas on a short-term basis. In return, the customers are committed to resell equivalent quantities of gas to Pan-Alberta from Alaskan or other Arctic supplies in the 1980's and 1990's. One feature of the scheme which has reportedly drawn forth additional gas supplies from producers is the initial price offered, about 38 cents/Mcf on average, with subsequent price escalation provisions. At the beginning of 1973, the company reported that final contract negotiations were under way on reserves sufficient to allow the removal of more than 2 billion cubic feet of gas per year. Current plans provide for applications to regulatory authorities early in 1973, allowing for shipments by late 1974.

No export applications came before the National Energy Board during 1972.

Outlook

Natural gas has many attributes as a premium fuel – not the least being its environmental preference. Whether because of these attributes or its cheapness relative to its quality, or a combination of many factors, there is a seemingly insatiable and waiting demand for Canadian natural gas in North America. However, for the first time since the large-diameter gas transmission lines were built in the 1950's demand is applying the pressures and supply is no longer pushing to find new markets. Indeed, gas supply has been losing ground recently. For example, gas reserves in the United States declined in 1969 for the first time since the American Gas Association began keeping records in 1946 and this decline has continued. In Canada, in 1971, after holding hearings to determine the adequacy of gas reserves, the National Energy Board found that there was no additional surplus gas available in Canada for export. In 1972, marketable Canadian gas reserves declined for the first time since the Canadian Petroleum Association began compiling reserve data in 1950. The longer-term outlook will therefore be conditioned by the amount of new gas that can be found and made available.

Other factors also are affecting outlook. For example, the Alberta government has reserved approval for increased exports from the province to TransCanada PipeLines Limited during the implementation of new policies relating to pricing and disposition of Albertan gas. TransCanada has indicated that increased volumes of gas are necessary to meet its customer requirements beginning late in 1973. Lacking the required provincial approvals, the company had somewhat reduced its proposed 1973 planned expansion to its system, to conform to the volumes of gas which can be removed from Alberta under existing licences.

Nevertheless, in the short term exports will continue to show some growth as shipments are built up to the maximum volumes allowed under existing licences but will level off to the amounts approved by the National Energy Board. As a result, exports are expected to average about 2,850 MMcf/d during 1973. Increased sales in Canada are expected to account for the bulk of the increase in output in 1973. Total domestic sales should average in excess of 3,300 MMcf/d and net withdrawals from Canadian fields should average approximately 8,200 MMcf/d.

Composition and uses of natural gas

Marketed natural gas consists chiefly of methane (CH_4) but small amounts of other combustible hydrocarbons such as ethane (C_2H_6) and propane (C_3H_8) may also be present. Methane is nonpoisonous and odourless but a characteristic odour is usually introduced into marketed natural gas as a safety measure. The heat value of natural gas averages about 1,000 British thermal units per cubic foot of gas.

Raw natural gas, as it exists in nature, may vary widely in composition. Besides the usually predominant methane, varying proportions of ethane, propane, butane and pentanes plus may be present. Water vapour is a normal constituent. Hydrogen sulphide, although not present in some Canadian natural gas, is commonly so abundant as to be an important source of sulphur. Other non-hydrocarbon gases which may be present, usually in small amounts, are carbon dioxide, nitrogen and helium.

The most important use of natural gas is as a fuel for space and water heating. Gas is now extensively used in cooking and is becoming common as a fuel for air conditioners, incinerators, dishwashers and laundry equipment. In industrial areas, such as southwestern Ontario, natural gas has been a boon to such industries as automobile plants, steel plants, metal-working firms, glass factories and food-processing industries. For example, in metallurgical processing, the clean, easily controlled flame of natural gas enables the desired temperatures to be attained in rolling, shaping, drawing and tempering steel. The constituents of natural gas have become major sources of raw material for the petrochemical industry. Ethane, seldom removed from natural gas at the field processing plant, is an important petrochemical feed-stock that is sometimes recovered from pipeline gas. Natural gas supplies basic raw material for ammonia, plastics, synthetic rubber, insecticides, detergents, dyes and synthetic fibres such as nylon, orlon and terylene. Important future uses may include gas fuel-cells and power-generator systems driven by gas turbines. Canada has recently become one of the world's largest producers of elemental sulphur, a byproduct recovered in the processing of sour gas (hydrogen sulphide bearing) from fields in western Canada.

Nepheline Syenite and Feldspar

G.H.K. PEARSE

Nepheline syenite is a white to whitish-grey, medium-grained igneous rock resembling granite in texture. It consists of nepheline, potash and soda feldspar, and accessory mafic minerals such as biotite, hornblende and magnetite. Although nepheline syenite is a rock type known to occur in many parts of Canada, its industrial application is limited to those deposits in which iron-bearing accessory minerals can readily be removed; its major uses are in the glass and ceramics industries.

Nepheline syenite as an industrial raw material was first developed in Canada, which for many years was the world's sole producer. Although the U.S.S.R. began mining nepheline syenite on the Kola Peninsula during the 1930's, the deposit was worked for its phosphate content. Byproduct nepheline syenite from the Kola deposit became important as a source of aluminum and is still being used for this purpose. In addition to Canada and the U.S.S.R., only Norway produces nepheline syenite.

Canada's nepheline syenite industry began in 1932 with the staking of five claims on Blue Mountain, 25 miles northeast of Peterborough. A long period of persistent efforts in technical and market research and development was necessary before this unique industry became established. Today there are two mills in operation on Blue Mountain processing rock from three quarries.

Over the years nepheline syenite has become preferred to feldspar as a source of essential alumina and the alkalis in glass manufacture. Its use has resulted in more rapid melting of the batch at lower temperatures than with feldspar, consequently reducing fuel consumption, lengthening the life of furnace refractories and improving the yield and quality.

Industrial uses for nepheline syenite other than glass manufacture are many and markets are expanding rapidly in ceramics, enamels, and as a filler in paints, papers, plastics and foam rubber.

Canadian production and developments

Production originates from two operations on Blue Mountain in Methuen Township, Peterborough County, Ontario. The deposit is pear-shaped, approximately 5 miles long and up to 1.5 miles wide. The iron content of the rock is distributed quite uniformly, but nonetheless, selective quarrying, blending of quarry material, and careful pit development are necessary to ensure a mill product capable of meeting consumer specifications. In general, the nepheline syenite zone is underlain by syenites and overlain by steeply dipping biotite schists. Nepheline syenite reserves are sufficient to satisfy demand for the foreseeable future.

Indusmin Limited, a subsidiary of Falconbridge Nickel Mines Limited, is the larger producer. The company's operation at Nephton, Ontario, was originally worked by its predecessor Canadian Nepheline, Limited. Ore is mined from two open pits, Cabin Ridge and Craig. Rock is blasted from the pit face and loaded by electrically powered shovels into trucks for haulage to an adjacent 1,000-ton-a-day mill at Nephton. The mill, built in 1956, operates three shifts a day, seven days a week producing several grades of nepheline syenite to meet a wide variety of markets. The various grades produced are based on combinations of differing mesh sizes and iron content. Iron-bearing minerals are almost totally removed by electromagnetic methods. Finished products are transported by rail to Havelock, Ontario, 18 miles south of the mill. From there, transportation is by rail to domestic and export markets. The United States accounts for about 65 per cent of sales.

International Minerals & Chemical Corporation (Canada) Limited (IMC) operates the other mill on the Blue Mountain deposit, about 4 miles east of the Indusmin operation. The mill, capable of producing some 600 tons a day of finished product, was constructed in mid-1956 on a part of the deposit originally staked in 1932 by the Canadian Flint and Spar Company, Limited. The mill operates three shifts daily, seven days a week and produces a variety of products based on mesh sizes and iron content suitable for many industrial uses. Rock is mined from an open pit adjacent to the mill; a certain degree of blending from various parts of the pit is required to ensure an acceptable mill feed. Ore reserves are sufficient for many years.

Production is railed to Havelock for distribution to various markets, approximately 90 per cent being exported to the United States. IMC produces three grades of nepheline syenite for glass, enamel, fibre and other applications.

In 1972, total nepheline syenite shipments amounted to 560,000 short tons valued at $7 million, a tonnage increase of 8 per cent from 1971. Revenue

Table 1. Canada, nepheline syenite production, exports and consumption, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)	517,190	6,206,014	560,000	7,065,000
Exports				
United States	386,450	4,860,000	417,529	5,334,000
Britain	2,568	51,000	9,770	137,000
Australia	5,224	107,000	2,621	59,000
Puerto Rico	1,908	31,000	3,406	54,000
Italy	955	22,000	1,208	31,000
France	342	11,000	895	27,000
Spain	275	8,000	708	18,000
Greece	792	20,000	658	18,000
Netherlands	306	9,000	380	11,000
Other countries	5,420	110,000	1,230	33,000
Total	404,240	5,229,000	438,405	5,722,000

Consumption[1] (available data)

	1970	1971^p
	(short tons)	
Glass and glass fibre	58,592	56,896
Whiteware	9,719	10,388
Frits	252	137
Paints and varnish	1,472	1,688
Others[2]	12,884	14,002^e
Total	82,919	83,091

Source: Statistics Canada.
[1] Adjusted – total and breakdown from Mineral Resources Branch. [2] Includes mineral wool, miscellaneous chemicals, gypsum products, rubber products, cleansers and detergents and other minor uses.
^{p}Preliminary; ^{e}Estimate.

from sales in 1972 showed an increase of 13 per cent over 1971, reflecting both a growth in sales volume and a price increase during the year.

From 1950 to 1962, annual shipments increased from 65,000 to 250,000 tons, an average growth rate of 17 per cent a year. Between 1963 and 1968 a growth rate of 9 per cent was realized. This dramatic growth was due largely to recognition by glassmakers of the superior properties, consistent quality, long-term reliable supply and low cost of nepheline syenite compared with feldspar. Sales were especially bouyant in 1968-69 because of a tight supply situation for feldspar in the United States. Upon return to more normal feldspar supply conditions in 1970, a minor decrease in nepheline syenite shipments occurred. However, in 1972 the former healthy growth rate resumed.

Other domestic occurrences

Nepheline syenite is known to occur in many localities in Canada, but to date, only the Blue Mountain deposit has proven to be amenable to mining and milling economically to produce material suitable for the glass and ceramic markets. Other occurrences are either too high in iron content or are too variable in chemical composition to allow large-scale open pit development.

An extensive body of nepheline syenite outcrops in the Bancroft area of Ontario. Small tonnages of this material were mined from 1937 to 1942 but the product proved unacceptable because of considerable variation in the nepheline content and an over-abundance of iron-bearing accessory minerals. Tontine Mining Limited (now Coldstream Mines Limited) discontinued exploration work in 1971 on a large nepheline syenite intrusive located near Port Coldwell, Ontario, after obtaining discouraging results from petrologic and metallurgical studies.

Nepheline syenite occurs in several localities in southern British Columbia, notably in the Ice River area, near Field, and in the Big Bend area on the Columbia River.

Nepheline is a common mineral constituent in the alkaline complexes of northern Ontario and southern Quebec but none of these deposits are as yet of economic significance.

Markets

In 1972, 78 per cent of Canada's nepheline syenite output was exported. Sales to the United States increased 8 per cent from 1971 and accounted for 95 per cent of total exports.

Canadian offshore sales were 20,876 short tons in 1972, an increase of 17 per cent over 1971. This reversed a declining trend that began in 1966 as a result of growing penetration of the European market by Norwegian nepheline syenite. Europe accounted for 68 per cent of Canada's overseas shipments. Most of the remainder went to Puerto Rico and Australia.

Domestic shipments increased to an estimated 121,600 tons in 1972, 8 per cent over 1971, which was a year of prolonged strikes in the glass container industry.

Canadian consumption normally accounts for approximately 20 per cent of producers' shipments and of this, 70 per cent is used in glass and glass fibre manufacture. Available data for 1971 and 1972 indicate an increase of 7 per cent in consumption for glass and glass fibre, little change in whiteware and mineral wool manufacture and a substantial expansion in use as a filler in paints, plastics and other applications.

For use in the glass industry, about 15 to 20 per cent by weight of the glass batch is nepheline syenite. Material with a size range of minus 30 mesh to plus 200 mesh and with an iron content of less than 0.1 per cent is required in the production of flintglass. An iron content as high as 0.6 per cent expressed as Fe_2O_3 is allowable for the manufacture of coloured glass. A typical chemical analysis for high-quality nepheline syenite produced in Canada for glass manufacture is:

Silica SiO_2	– 60.00
Alumina Al_2O_3	– 23.60
Iron Fe_2O_3	– 0.07
Lime CaO	– 0.30
Magnesia MgO	– 0.10
Potash K_2O	– 5.30
Soda Na_2O	– 10.20
Loss-on-ignition	– 0.50

A growing market is developing for finely ground material in the whiteware industry. The finer grades used for ceramic applications are produced by reducing the basic minus 30 mesh material in pebble mills. In ceramics, nepheline syenite is used as both a body and glaze ingredient. High-purity material in the minus 200 – plus 375 mesh size and with an iron content of 0.07 per cent Fe_2O_3 or less is most frequently used. Products utilizing this material include bathroom fixtures, vitreous enamels for appliances, china, ovenware, electrical porcelain and ceramic artwares.

Table 2. Canada, nepheline syenite production and exports, 1963-72

	Production[1]	Exports
	(short tons)	
1963	254,000	203,262
1964	290,300	226,971
1965	339,982	247,200
1966	366,696	263,624
1967	401,601	307,613
1968	426,595	323,182
1969	500,571	395,613
1970	486,667	387,947
1971	517,190	404,240
1972[p]	560,000	438,405

Source: Statistics Canada.
[1] Producers' shipments.
[p] Preliminary.

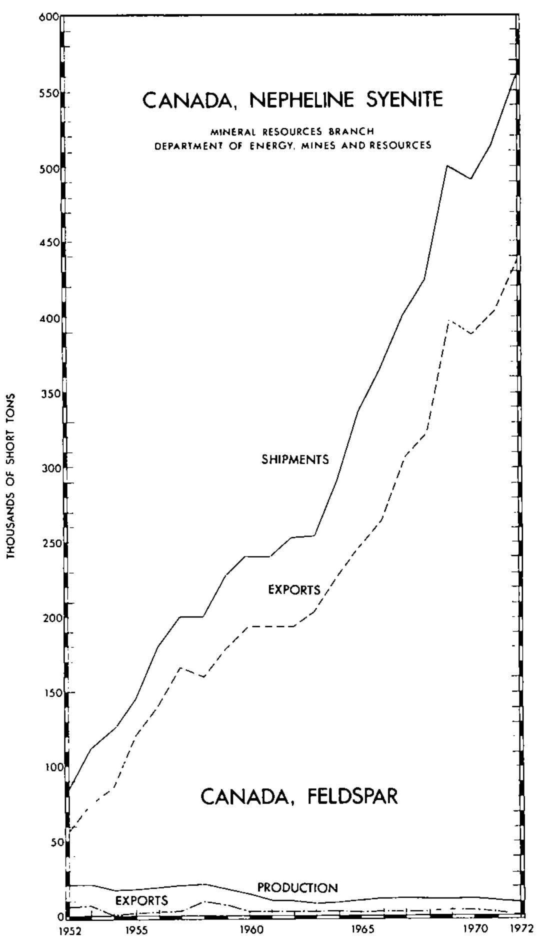
Very finely ground material is being increasingly used as a filler in plastics, foam rubber and paints. Fine-grinding down to 10 microns is accomplished in pebble and fluid-energy mills. The very fine grain size, high reflectance and low oil adsorption are important physical characteristics which make nepheline syenite an excellent filler comaterial in such finished products as paints, vinyl furniture upholstery, foam rubber cushions, foam rubber carpet backings, and floor and wall tile.

A low-grade nepheline syenite is sold in bulk for use in the manufacture of fibre glass and for glazing on brick and tile. Some material with high iron content is used in the manufacture of mineral wool and as an aggregate.

World review

The Norsk Nefelin Division of Christiania Spigerwerk is western Europe's only producer of nepheline syenite. Production began in 1961 and increased steadily from 23,000 metric tons in 1963 to 80,000 metric tons in 1968. Operations at the plant near Hammerfest in northern Norway have recently been expanded and capacity in 1971 was 175,000 metric tons per year. Exports for 1972 are estimated at 160,000 metric tons. The lenticular deposit is over 1 mile long and at least 750 feet deep. Unlike Canadian producers, Norsk Nefelin mines underground, drilling and blasting by conventional techniques. Nepheline syenite is supplied to the glass, ceramic and enamel industries in two main grades; glass grade is about 28 Tyler mesh and ceramic grade 200 Tyler mesh. The finer-mesh ceramic grade material is usually shipped in bags whereas the coarser glass grade is shipped in bulk to European markets. The company employs a modern fleet of coasters on long-term charter and ships finished products to storage and distribution centres in major market areas.

Nepheline syenite is an important source of alumina for aluminum production in the Soviet Union. Very large deposits occur near Kirovsk in the Kola Peninsula and also in the Lake Baikal region of Siberia. The Kola deposits were first mined in the 1930's for phosphate. Byproduct nepheline syenite that contains 30 per cent Al_2O_3 is recovered for use in aluminum production. In the process used to extract alumina, limestone is added to the syenite and the mix is treated to yield anhydrous alumina, soda, potash and cement.



Outlook

The outlook for nepheline syenite continues to be good. Canadian shipments to Europe increased in 1972 for the first time since 1965 but European markets will remain vulnerable to competition from Norwegian nepheline syenite. However, these account for less than 5 per cent of Canada's total sales and therefore will have little effect on over-all developments in the industry.

The market for micronized material used as a filler and extender in plastics, paint, rubber, paper, etc., has grown more rapidly than consumption for glassmaking and further diversification and growth of these markets is expected.

The phenomenal growth rate enjoyed by the nepheline syenite industry during the 1950's and early 60's has moderated as markets formerly supplied by feldspar approach saturation. The glass industry continues to prosper, however, and with the expansion of other uses, a growth rate of 7 per cent per year is anticipated for the next 5 years.

Prices and tariffs

Nepheline syenite prices vary from low-purity, crushed rock in bulk, at $5.40 a ton, to $29 a ton for high-purity products. The price of nepheline syenite used in the glass industry is around $14 a ton fob plant.

The largest export market is the United States where entry is duty-free.

FELDSPAR

Feldspar is the name of a group of minerals that are aluminum silicates of potassium, sodium and calcium. It is used in glassmaking and as a source of alumina; and the alkalis, in cleaning compounds as a moderate abrasive, as a flux coating on welding rods, etc. High-calcium feldspars, such as labradorite, and feldspar-rich rocks like anorthosite find limited use as building stones and for other decorative purposes. Dental spar, which is used in the manufacture of artificial teeth, is a pure white feldspar free of iron and mica.

Feldspars occur in many rock types but commercially viable deposits are mostly restricted to coarse-grained granite pegmatites from which the mineral is generally hand-cobbed to remove quartz and other unwanted associated minerals. It is then ground to the desired size. Nearly all feldspar produced in Canada has come from pegmatites in the Precambrian rocks of southern Ontario and southwestern Quebec.

The trend toward standardization of methods in glass manufacture demanding uniformity of quality has favoured the use of nepheline syenite in a wide range of products formerly utilizing feldspar.

Canadian production and developments

International Minerals & Chemical Corporation (Canada) Limited, the only Canadian producer of feldspar, closed down operations at its mine and mill at Buckingham, Quebec in mid-1972.

As a result of substitution by nepheline syenite, output of feldspar has declined steadily from 55,000 tons in 1947 to 10,000 tons in 1961, a level that persisted throughout the 1960's to the present.

Several local producers of high-value dental spar had delivered small tonnages to IMC's mill at Buckingham until the recent mill closure.

Centex, a joint university-industry-government body in Manitoba, initiated an investigation in 1971 into byproduct recovery of, and possible markets for, feldspar and other minerals from mining waste in the province. Tantalum Mining Corporation of Canada Limited mines tantalum from a pegmatite containing abundant feldspar at Bernic Lake, Manitoba and the company is actively studying recovery and market potential of a clean quartz-feldspar product.

Markets

Substitution of alternative materials for feldspar in ceramic manufacture has been less severe than in the manufacture of glass. The principal reason is that raw material costs are low in the ceramic industry in relation to total manufacturing costs and manufacturers adopt a new raw material only after cautious trial use and extensive evaluation. Further, while the higher alumina content of nepheline syenite has been a decisive factor in the replacement of feldspar in glass manufacture, a high alumina content is less critical in ceramic manufacture. In ceramics, potash feldspar is used to bind the ceramic mix into what the industry terms a 'body'. Potash feldspar utilized for ceramics is usually required to contain not less than 8 per cent K_2O and preferably over 10 per cent K_2O. The soda (Na_2O) content should be as low as possible, ideally zero, and the iron (Fe_2O_3) content under 0.1 per cent. Feldspar is important as a flux in the firing of whiteware bodies and glazes and is used in Canada

Table 3. Canada, feldspar production, 1971-72; consumption, 1970-71

	1971	1972^p
Production[1]	10,774st	10,000st
	$216,039	$200,000
Consumption[2] (available data)	1970	1971^p
	(short tons)	
Whiteware	6,133	7,154
Porcelain enamel	358	244
Soaps and cleaning compounds	564	550^e
Other[3]	485	908
Total	7,540	8,856

Source: Statistics Canada.
[1]Producers' shipments. [2]Breakdown by Mineral Resources Branch. [3]Includes artificial abrasives, electrical apparatus, glass paper and other minor uses.
^{p}Preliminary; ^{e}Estimate.

Table 4. Canada, feldspar production and trade, 1963-72

	Production[1]	Imports	Exports	Consumption
	(short tons)			
1963	8,608	2,600	3,282	6,009
1964	9,149	..	3,386	7,493
1965	10,904	..	3,746	8,338
1966	10,924	..	3,419	8,528
1967	10,394	..	..	8,571
1968	10,620	..	..	7,343
1969	12,385	..	..	7,635
1970	10,656	..	..	7,540^r
1971	10,774	..	..	8,856
1972^p	10,000	..	..	..

Source: Statistics Canada.
[1]Producers' shipment.
^{p}Preliminary; .. Not available; ^{r}Revised.

Table 5. World production of feldspar, 1971-72

	1971	1972^e
	(short tons)	
United States	832,000	868,000
West Germany	370,000	275,000
Italy	237,000	241,000
Norway	160,000	168,000
France	150,000	151,000
Japan	64,000	62,000
Sweden	39,000	39,000
Other countries	946,000	896,000
Total	2,798,000	2,800,000

Source: U.S. Bureau of Mines Commodity Data Summaries, January 1973.
^{e}Estimate.

principally in the manufacture of electric porcelain and vitreous sanitary ware. It must be minus 325 mesh and have a very low quartz and iron content – Fe_2O_3 should not exceed 0.1 per cent. For cleaning compounds, feldspar should be white and free of quartz. In the United States, in recent years, there has been a marked increase in the consumption of a naturally occurring feldspar-silica mixture for glass manufacture. Normally the mixture contains from 30 to 50 per cent feldspar. Should Tantalum Mining Corporation of Canada Limited be successful in producing a similar product, it would most likely be used for glassmaking in western Canada.

Prices

United States feldspar prices in U.S. currency as quoted in Engineering and Mining Journal of December 1972
(per short ton, fob mine or mill, carload lots, depending on grade)

	($)
North Carolina	
40 mesh, flotation	14-21
20 mesh, flotation	12
200 mesh, flotation	21.50-27
Georgia	
200 mesh	24.50
325 mesh	25.50
40 mesh, granular	20
Connecticut	
200 mesh	22.50
325 mesh	23.50
20 mesh, granular	15.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
29600-1	Feldspar, crude	free	free	free
29625-1	Feldspar, ground but not further manufactured	free	7.5%	30%

United States

		On and After January 1		
Item No.		1970	1971	1972
522.31	Feldspar, crude	5¢ per ton	2¢ per ton	free
522.41	Feldspar, crushed ground or pulverized	5%	4%	3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Nickel

C.J. CAJKA

The depressed nickel market, which developed in late 1970, prevailed through 1971 and into 1972. Fortunately, major world economies showed good expansion throughout 1972 with the result that the nickel market improved considerably, especially during the latter half of 1972. This trend is expected to continue into 1973 and 1974.

As a consequence of lagging nickel demand and accumulating inventories, the major nickel producers in noncommunist countries deferred expansion projects, reduced production and set upon a program to minimize production costs. Effects of these economizing measures were most dramatically felt in the Thompson and Sudbury areas of Canada where The International Nickel Company of Canada, Limited (Inco) reduced nickel production by about 20 per cent and Inco's Canadian employment by about 18 per cent from 1970 levels.

There was no evidence at year-end 1972 that production capacity, placed on a standby basis, would soon be reactivated. However, nickel deliveries were on an increasing trend in early 1973 and it is expected that producer inventories will decline to normal levels by the end of that year. Canadian nickel production should begin to expand again in early 1974.

Canada maintained its position as the leader in nickel production, accounting for about 38 per cent of total world output. U.S.S.R., with about 20 per cent of production, and New Caledonia, with an estimated 18 per cent, were the two next largest producers.

Canadian mine production of nickel in 1972 declined to 258,087 tons, valued at $702,126,000, from 294,341 tons, valued at $800,064,068 in 1971. This was the second consecutive year for a decline in both quantity and value. Consumption of nickel in the noncommunist world was about 455,000 tons. The comparable usage in 1971 was 412,500 tons.

There was one round of price increases during 1972. In September, the producer price for electrolytic nickel (Class I type) was increased from U.S.$1.33 to U.S.$1.53. Other nickel products were increased similarly but forms such as nickel oxide sinter and ferronickel (Class II type) underwent smaller changes, thereby emphasizing the two-product lines segregation of the nickel industry. All Canadian prices are now based on the U.S. price converted to Canadian funds by the official exchange rate.

Canadian operations and developments

Ten companies mined nickel ores in four provinces and one territory during 1972. By far, the largest producer was The International Nickel Company of Canada, Limited (Inco), which operated mines in Ontario and Manitoba. Falconbridge Nickel Mines Limited, the second largest producer, treated ores from its mines also located in these same provinces. In addition to Ontario and Manitoba, a small amount of nickel ore was mined in Quebec, British Columbia and the Yukon Territory. Inco, Falconbridge, and Sherritt Gordon Mines, Limited each have integrated mine-concentrator-smelter-refinery complexes where they process ore to the metal stage.

Three new nickel-copper mines and two concentrators commenced operation in 1972. One mine was closed because reserves were depleted, another, including a concentrator, for lack of concentrate sales and a third as the final stage of voluntary production curtailment. The Falconbridge nickel-iron refinery, after two years of intensive effort to put it on a viable basis, was officially shut down for technical as well as cost reasons. Also, at Falconbridge, the pyrrhotite operation, which recovered small quantities of by-product nickel, was terminated.

The International Nickel Company of Canada, Limited is the world's largest producer of nickel. Deliveries in 1972 of 212,540 tons accounted for almost 47 per cent of consumption in the noncommunist world. The company operated twelve mines, five concentrators and two smelters in the Sudbury district, a mine and concentrator at Shebandowan, northwestern Ontario, and a nickel refinery and additives plant at Port Colborne, Ontario. In Manitoba, Inco operated three mines, one concentrator, one smelter and a nickel refinery at Thompson. At Copper Cliff (now amalgamated with Sudbury), Inco completed construction of its new nickel refinery and planned for commercial production in mid-1973. The new refinery, with a designed annual capacity of 50,000 tons of nickel pellets and 12,500 tons of nickel powder, employs the company's pressure carbonyl process. Also in Ontario, Inco placed its new 2,500-ton-a-day Shebandowan mine and concentrator into production and commissioned its new S nickel rounds and foundry additives plants at Port Colborne in 1972.

As the final stage of its three-phase cutbacks that were initiated in 1971, Inco reduced production an

Table 1. Canada, nickel production, trade and consumption, 1971-72

	1971		1972p	
	(short tons)	($)	(short tons)	($)
Production[1]				
All forms				
Ontario	215,753	583,946,348	189,073	513,301,000
Manitoba	76,568	210,562,711	65,571	179,050,000
British Columbia	1,272	3,497,420	1,665	4,730,000
Yukon	–	–	1,620	4,598,000
Quebec	748	2,057,589	158	447,000
Total	294,341	800,064,068	258,087	702,126,000
Exports				
Nickel in ores, concentrates and matte and speiss[2]				
United Kingdom	55,572	150,016,000	52,200	145,780,000
Norway	50,810	127,123,000	46,917	111,756,000
Japan	10,090	24,177,000	12,127	27,525,000
United States	–	–	87	187,000
Other countries	21	47,000	–	–
Total	116,493	301,363,000	111,331	285,248,000
Nickel in oxide				
United States	28,451	66,865,000	27,854	65,475,000
Belgium-Luxembourg	4,067	10,461,000	4,308	10,579,000
United Kingdom	9,169	21,692,000	2,131	5,113,000
Australia	879	2,293,000	858	2,073,000
Sweden	–	–	729	1,852,000
Spain	–	–	546	1,294,000
Other countries	189	445,000	210	559,000
Total	42,755	101,756,000	36,636	86,945,000
Nickel and nickel alloy scrap				
United States	926	1,062,000	1,694	1,928,000
Japan	88	226,000	254	578,000
Italy	510	1,690,000	96	283,000
India	26	66,000	17	45,000
Other countries	508	1,283,000	71	91,000
Total	2,058	4,327,000	2,132	2,925,000
Nickel anodes, cathodes, ingots, rods				
United States	85,437	207,675,000	94,760	232,053,000
United Kingdom	29,292	71,181,100	9,392	22,723,000
People's Republic of China	276	743,000	6,188	15,927,000
Japan	2,006	5,477,000	3,363	9,228,000
Italy	1,972	6,372,517	1,223	3,593,000
Australia	1,712	4,715,000	1,041	2,812,000
Taiwan	199	543,000	888	2,415,000
Brazil	574	1,674,000	720	2,044,000
India	894	2,774,000	638	1,686,000
Belgium-Luxembourg	–	–	612	1,481,000
Sweden	296	790,000	411	1,101,000
Mexico	877	2,402,000	374	1,048,000
Other countries	1,944	6,128,020	1,289	3,591,000
Total	125,479	310,474,637	120,899	299,702,000
Nickel and nickel alloy, fabricated material, nes				
United States	1,287	4,148,000	2,833	8,542,000
Netherlands	222	933,000	557	2,006,000
Hungary	384	1,628,000	213	858,000

Table 1 (concl'd)

	1971		1972[p]	
	(short tons)	($)	(short tons)	($)
Exports (cont.)				
Italy	35	133,678	307	856,000
United Kingdom	54	205,000	235	716,000
South Africa	17	56,000	139	328,000
Japan	14	53,000	78	231,000
Other countries	543	1,872,000	205	573,000
Total	2,556	9,028,678	4,567	14,110,000
Imports				
Nickel in ores, concentrates and scrap				
Australia	9,134	17,471,000	9,859	18,435,000
French Oceania	3,053	1,273,000	4,730	8,919,000
United States	4,238	5,035,000	6,426	6,105,000
United Kingdom	5,225	3,734,000	3,020	2,006,000
France	–	–	110	176,000
Others	89	78,000	243	235,000
Total	21,739	27,591,000	24,388	35,876,000
Nickel anodes, cathodes, ingots, rods				
Norway	13,324	37,079,000	17,770	50,446,000
United States	43	142,000	156	485,000
Australia	–	–	53	132,000
West Germany	40	95,000	21	86,000
Other countries	659	1,827,000	–	–
Total	14,066	39,143,000	18,000	51,149,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	386	1,503,000	472	1,617,000
France	–	–	27	105,000
United Kingdom	6	22,000	1	1,000
West Germany	26	111,000	–	–
Total	418	1,636,000	500	1,724,000
Nickel and alloy plates, sheet strip and flat products				
United States	1,260	4,595,000	2,408	8,185,000
West Germany	26	69,000	61	191,000
Other countries	15	78,000	11	68,000
Total	1,301	4,742,000	2,480	8,444,000
Nickel and nickel alloy pipe and tubing				
United States	401	3,546,000	455	3,770,000
West Germany	92	819,000	86	733,000
Other countries	...	2,000	11	42,000
Total	493	4,367,000	552	4,545,000
Nickel and alloy fabricated material, nes				
United States	262	1,350,000	237	1,185,000
United Kingdom	55	315,000	154	738,000
Australia	1	5,000	150	374,000
Other countries	19	100,000	19	106,000
Total	337	1,770,000	560	2,403,000
Consumption[3]	8,583	..	10,093	..

Source: Statistics Canada.
[1]Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exports. [2]For refining and re-export. [3]Consumption of nickel, all forms (refined metal and in oxide and salts) as reported by consumers.
[p]Preliminary; – Nil; nes Not elsewhere specified; . . . Less than 1,000 lb; . . Not available.

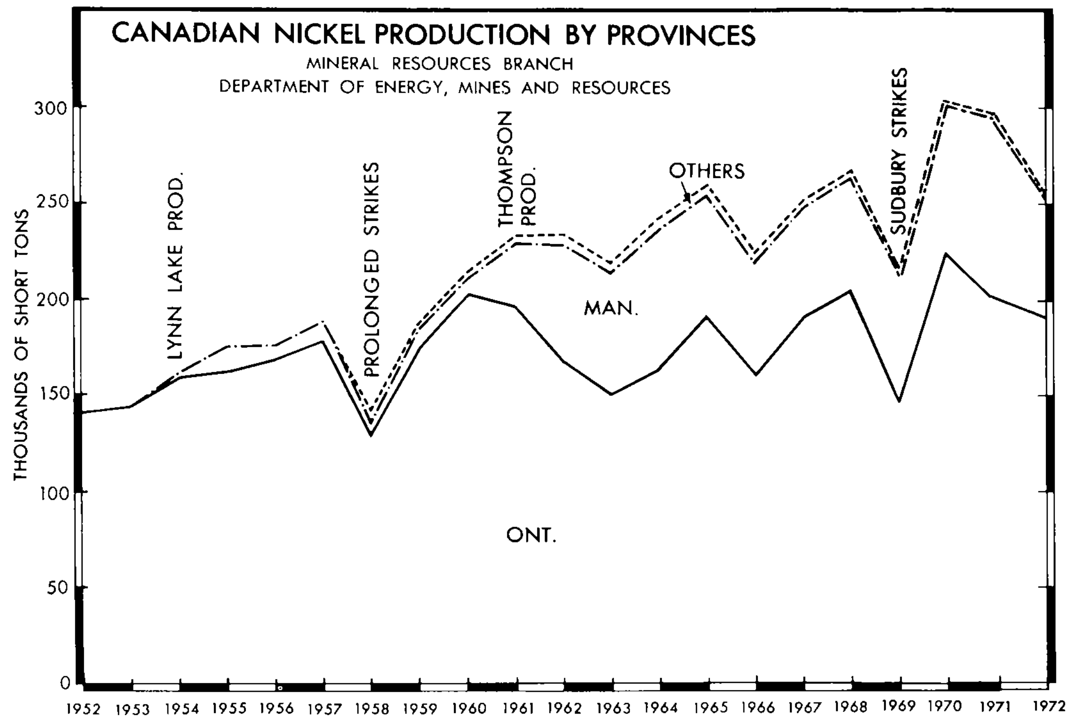


Table 2. Nickel, production, trade and consumption, 1963-72

	Production[1]	Exports: In Matte, etc.	Exports: In Oxide Sinter	Exports: Refined Metal	Exports: Total	Imports[2]	Consumption[3]
	(short tons)						
1963	217,030	83,392	15,208	109,156	207,756	10,973	5,866
1964	228,496	74,766	35,800	128,330	238,896	10,444	6,899
1965	259,182	82,327	40,956	135,197	258,480	12,172	8,924
1966	223,610	83,586	33,631	132,712	249,929	28,916	8,608
1967	248,647	83,662	34,204	128,659	246,525	9,557	8,767
1968	264,358	95,527	42,058	127,095	264,680	11,394	11,233
1969	213,612	76,976	29,009	104,243	210,228	12,601	12,094
1970	305,881	96,659	43,895	153,203	293,757	11,826	11,794
1971	294,341	116,493	42,755	125,479	284,727	14,066	8,583
1972[p]	258,087	111,331	36,636	120,899	268,866	18,000	10,093

Source: Statistics Canada.
[1]Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2]For 1963 nickel, semifabricated, comprising nickel and nickel alloys in ingot blocks, bars, rods, strip, sheet, etc.; 1964 and subsequent years, refined nickel, comprising anodes, cathodes, ingots, rods and shot. [3]Consumption of nickel, all forms (refined metal, and in oxides and salts), as reported by consumers.
[p]Preliminary; . . Not available.

Table 3. Producing Canadian nickel mines, 1972 and [1971]

Company and Location	Mill or Mine Capacity	Grade of Ore: Nickel	Grade of Ore: Copper	Ore Produced	Contained Nickel Produced	Remarks
	(tons ore/day)	(%)	(%)	(tons)	(tons)	
Quebec						
Renzy Mines Limited, Hainault Township	1,000 [1,000]	0.49 [0.43]	0.58 [0.55]	63,630 [314,630]	202 [830]	Smelter contract terminated and mine closed April 4, 1972. Plans for dewatering pit and resuming production.
Société Minière d'Exploration Somex ltée, Bickerdike Township, Lac Edouard	240 [–]	.. [–]	.. [–]	.. [–]	.. [–]	Production began October 1972. Plans to increase mill capacity to 250-300 tpd.
Ontario						
Consolidated Canadian Faraday Limited, Werner Lake Division, Gordon Lake	1,200 [1,100]	0.78 [0.83]	0.37 [0.35]	56,696 [99,731]	345 [638]	Mine closed August 1972 because ore reserves exhausted. Mills ore from Dumbarton mine.
Falconbridge Nickel Mines Limited, East, Falconbridge, Fecunis Lake, Hardy-Boundary, Longvack South, North, Onaping and Strathcona mines, Falconbridge	3,000 (Falconbridge) 6,600 (Strathcona) 2,500 (Fecunis Lake) 1,500 (Hardy)	.. [..]	.. [..]	4,199,000 [4,703,000][2]	44,832[1] [49,932][1]	Preparations to open pit crown pillar at Hardy mine. Production at Hardy mill discontinued in 1972. Pyrrhotite plant closed April 1972.
The International Nickel Company of Canada, Limited, Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Little Stobie, and Maclennan mines, Sudbury	35,000 (Clarabelle) 11,400 (Creighton) 24,000 (Frood-Stobie) 6,200 (Levack)	.. [..]	.. [..]	15,894,577[3] [21,847,700]	212,540[1] [171,225][1]	Production suspended at Crean Hill mine in 1972. Ore reserves exhausted at Maclennan mine October 1972. Creighton mill placed on standby basis in 1971.
Shebandowan mine, Shebandowan	2,500 [–]	.. [–]	.. [–]	See above[3]	See above[1]	Production began July 1972.

Table 3 (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Nickel	Grade of Ore: Copper	Ore Produced	Contained Nickel Produced	Remarks
Ontario (cont.)	(tons ore/day)	(%)	(%)	(tons)	(tons)	
Texmont Mines Limited, Bartlett and Geikie Townships, Timmins	500 [500]	0.88 [. .]	– –	126,506 [74,240]	756 [401]	Mine closed November 1972. Concentrates are stockpiled.
Manitoba						
Dumbarton Mines Limited, Bird River	1,100 [800]	0.86 [0.86]	0.28 [0.32]	325,766 [299,480]	2,252 [2,075]	Ore trucked to Consolidated Faraday mill.
Falconbridge Nickel Mines Limited, Manibridge Mine, Wabowden	1,000 [1,000]	. . [. .]	. . [. .]	166,399 [. .]	44,832[1] [42,932][1]	Mill operating at less than two thirds capacity because of limited mine output.
The International Nickel Company of Canada, Limited, Birchtree, Pipe, and Thompson mines, Thompson	18,400 [18,400]	. . [. .]	. . [. .]	3,043,648 [4,776,678]	212,540[1] [171,225][1]	Production reduced at Birchtree mine.
Sherritt Gordon Mines, Limited, Lynn Lake	3,500 [3,500]	0.67 [0.66]	0.38 [0.41]	995,000 [1,158,000]	5,177 [5,825]	Converting to cut-and-fill mining methods from blast-hole stoping. Mill placed on 5-day week. Ore reserves declining and largely in *N* and *O* ore zones.
British Columbia						
Giant Mascot Mines Limited, Hope	1,875 [1,750]	0.68 [0.77]	0.38 [0.39]	389,894 [260,241]	1,966 [1,625]	Production from upper sections of Climax and Chinaman zones.
Yukon Territory						
Hudson-Yukon Mining Co., Limited, Wellgreen mine, Kluane Lake	600 [–]	2.05 [–]	1.35 [–]	112,451 [–]	1,840 [–]	Production began May 1972. Scheduled to close in early 1973 because of unforeseen irregularities in orebody.

Source: Corporate annual reports and data provided by companies.
[1]Total nickel deliveries. [2]Includes Manibridge. [3]Includes Shebandowan.
. . Not available; – Nil.

Table 4. Prospective[1] Canadian nickel mines

Company and Location	Mill Capacity[2] and Ore Grade	Year Production Expected	Destination of Nickel Concentrates	Remarks
	(%)			
Quebec				
Renzy Mines Limited, Hainault Township	1,000 Ni(0.69) Cu(0.72)	. .	. .	Plan to dewater open pit during 1973.
Ontario				
Falconbridge Nickel Mines Limited, Falconbridge,	. . Ni(. .) Cu(. .)	. .	Falconbridge	
Fraser mine				Deferred
Lockerby mine				Some underground developments, mine planning, and engineering studies in 1972.
Thayer Linsley mine				Deferred
Onex mine				Deferred
The International Nickel Company of Canada, Limited, Sudbury,	– Ni(. .) Cu(. .)		Sudbury	
Crean Hill		. .		Suspended and placed on standby in 1972.
Levack West		. .		2,500 tpd to company's mill.
Murray		. .		Suspended and placed on standby in 1971.
Totten		. .		Development suspended and placed on standby in 1972.
Kanichee Mining Incorporated, Strathy Township, Temagami	500 Ni(0.42) Cu(0.75)	1973	. .	Open pit scheduled for production in summer 1973.
Noranda Mines Limited, Timmins, Langmuir mine	700 Ni(1.87)	1973	. .	Production scheduled for mid-1973.
Manitoba				
The International Nickel Company of Canada, Limited, Thompson, Soab mine	– Cu(. .) Ni(. .)	. .	Thompson	Production suspended in 1971.

Sources: Corporate annual reports and technical press.
[1]Mines with announced production plans. [2]Mill capacity in tons of ore a day.
. . Not available; – Nil.

additional 10 per cent by April of 1972. The first curtailments were announced in August 1971 and these were followed in October to give a total reduction in 1971 of 22 per cent. The company notes in its 1972 annual report that over-all nickel production was reduced by about 20 per cent from the level attained in 1970. The 1972 curtailments included closing the Crean Hill mine, Creighton mill and

Coniston smelter, all in the Sudbury region, and reduced production from the Birchtree mine near Thompson and the Stobie mine at Sudbury. Inco now has four mines being maintained on a standby basis: Totten, Crean Hill and Murray in Ontario, and Soab in Manitoba. Ore reserves at the Maclennan mine, Sudbury area, were depleted in 1972 and the mine was closed. For the first time, the company scheduled a three-week shutdown of all plants in Ontario for the 1972 summer vacation.

At midyear, Inco completed construction on its 1,250-foot stack to serve all copper and nickel smelting operations at Sudbury. The company is developing one new mine in the Sudbury area, the Levack West mine, with production likely in 1975-76.

Falconbridge Nickel Mines Limited operated eight mines, four concentrators and one smelter in the Sudbury area of Ontario. The Manibridge project, a mine and concentrator operation located near Wabowden in Manitoba, was brought to production by Falconbridge during 1971. Manibridge concentrate is smelted at Falconbridge. All matte produced at Falconbridge is shipped to the company's refinery in Norway.

In a move to offset escalating costs and to moderate nickel output, Falconbridge announced plans to reduce production by 5 per cent, effective April 1972. Operations were temporarily suspended at the Hardy mill in April 1972, although the sand fill and concentrate drying facilities were not affected. Consistent with its policy to meet more stringent environment requirements, Falconbridge closed its pyrrhotite plant after 17 years of operation. With this termination, small amounts of byproduct nickel, which were formerly recovered, will be wasted. Major repairs were made to the smelter stack during the first two weeks of August and most employees were allowed to take vacations during this period. The company has deferred work on four new mines that it was developing in the Sudbury area.

Falconbridge's Manibridge mill in northern Manitoba operated at less than two thirds capacity because sufficient mine output could not be attained. Ground control problems and a shortage of skilled labour continue to restrict ore production.

Disappointing operating results at the nickel-iron pellet refinery led to the decision by Falconbridge to close the complex, including a sulphur recovery plant, in December 1972. The company had attempted to put the complex on an economic footing over a two-year period but was unable to resolve the technical and cost problems. An attempt is now being made to establish an alternative process to treat pyrrhotite concentrate by using a part of the refinery complex. Feasibility studies are not expected to be conclusive for at least two more years.

The third-largest Canadian nickel producer is Sherritt Gordon Mines, Limited. Sherritt Gordon continued to operate its Lynn Lake, Manitoba, nickel-copper mine and concentrator but ore production and grade have been decreasing over the past few years. As a result of redefining ore reserves for extraction by cut-and-fill mining methods instead of the formerly used blasthole stoping method, the mine is expected to be profitable for at least the next two or three years.

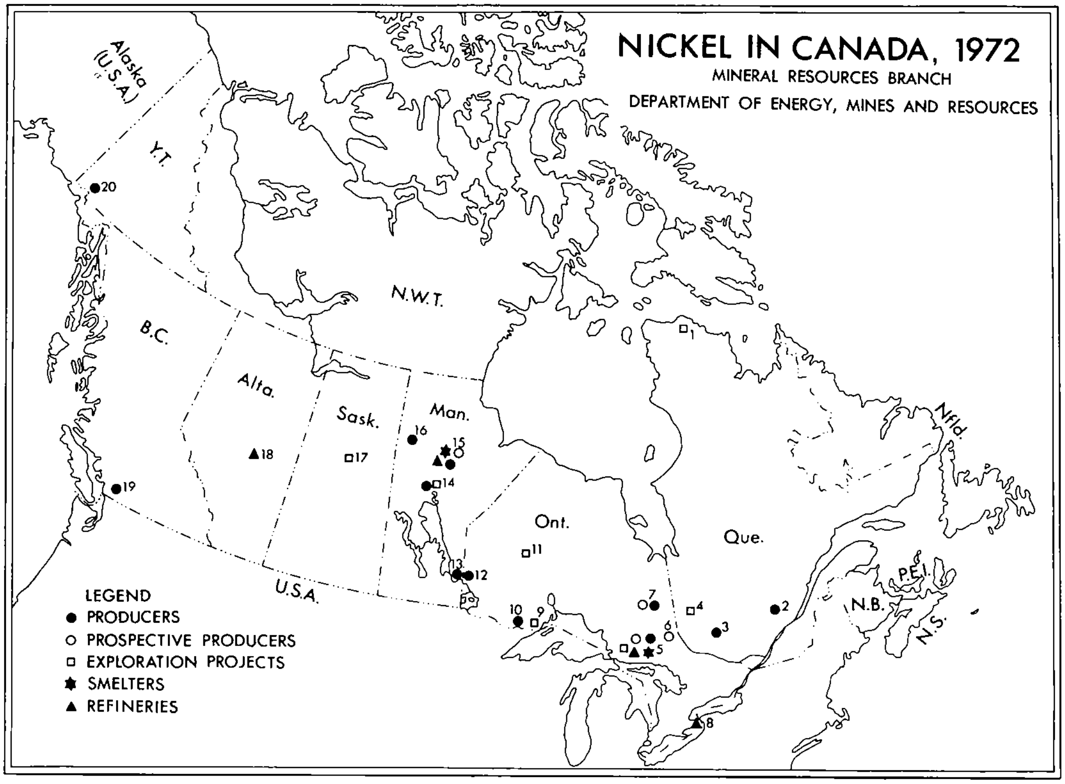
Lynn Lake concentrate is shipped to the Sherritt Gordon hydrometallurgical refinery in Fort Saskatchewan, Alberta. This refinery managed to operate at a record level during 1972 by using additional feed, obtained on both a purchase and toll-refining basis, from New Caledonia and Australia. Nickel production in 1972 totalled 18,659 tons: 4,240 tons from Lynn Lake, 3,830 from purchased feed and 10,589 from toll-refined feed. In a continuing policy to secure concentrate and matte for the refinery, Sherritt Gordon has negotiated concentrate and matte sales agreements with Giant Mascot Mines Limited and Société Minière d'Exploration Somex ltée in Canada and with Poseidon N.L. of Western Australia. The company has agreed in principle to an arrangement to purchase concentrate from the Australian Redross mine. These commitments will assure a constant flow of feed to the refinery for at least the next five years.

Renzy Mines Limited suspended production at its open pit mine in Hainault Township, Quebec, in April 1972, when the smelter contract with Falconbridge was terminated. No alternative market has yet been found for Renzy nickel-copper concentrate but the company has announced plans to dewater the open pit in 1973. Société Minière d'Exploration Somex ltée began production in October 1972 from a small nickel-copper deposit located at Lac Edouard, Quebec.

Producers

(numbers appear on accompanying map)

2. Société Minière d'Exploration Somex ltée (Lac Edouard)
3. Renzy Mines Limited (Hainault Township)
5. Falconbridge Nickel Mines Limited (East, Falconbridge, Fecunis Lake, Hardy-Boundary, Longvack South, North, Onaping and Strathcona mines)
   The International Nickel Company of Canada, Limited (Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Little Stobie and Maclennan mines)
7. Texmont Mines Limited (Timmins)
10. The International Nickel Company of Canada, Limited (Shebandowan mine)
12. Consolidated Canadian Faraday Limited (Gordon Lake)
13. Dumbarton Mines Limited (Bird River)



14. Falconbridge Nickel Mines Limited (Manibridge mine)
15. The International Nickel Company of Canada, Limited (Birchtree, Pipe and Thompson mines)
16. Sherritt Gordon Mines, Limited (Lynn Lake)
19. Giant Mascot Mines Limited (Hope)
20. Hudson-Yukon Mining Co., Limited (Wellgreen mine)

Prospective Producers

3. Renzy Mines Limited. Suspended in 1972 (Hainault Township)
5. Falconbridge Nickel Mines Limited (Fraser, Lockerby, Onex and Thayer Linsley mines)
   The International Nickel Company of Canada, Limited (Crean Hill, Murray and Totten mines – suspended in 1971-72; Levack West mine)
6. Kanichee Mining Incorporated (Temagami)
7. Noranda Mines Limited (Timmins)
15. The International Nickel Company of Canada, Limited (Soab mine)

Nickel Exploration Projects

1. New Quebec Raglan Mines Limited (Ungava)
   Expo Ungava Mines Limited (Ungava)
4. Dumont Nickel Corporation (Launay Township)
5. The International Nickel Company of Canada, Limited (Cryderman, North Range, Victoria and Whistle mines)
9. Great Lake Nickel Limited (Pardee Township)
11. Union Minière Explorations and Mining Corporation Limited (Pickle Crow)
14. Bowden Lake Nickel Mines Limited (Bowden Lake and Bucko Lake mines)
17. National Nickel Ltd. and Cadillac Explorations Limited (Nemeiben Lake)

Smelters

5. Falconbridge Nickel Mines Limited (Falconbridge)
   The International Nickel Company of Canada, Limited (Coniston – suspended in 1971; Sudbury)
15. The International Nickel Company of Canada, Limited (Thompson)

Refineries

5. Falconbridge Nickel Mines Limited. Nickel-iron refinery (Falconbridge)
   The International Nickel Company of Canada, Limited. Scheduled for production in 1973 (Sudbury)
8. The International Nickel Company of Canada, Limited (Port Colborne)
15. The International Nickel Company of Canada, Limited (Thompson)
18. Sherritt Gordon Mines, Limited (Fort Saskatchewan)

Table 5. Nickel exploration projects

Company and Location	Indicated ore	Grade of ore	Remarks
	(tons)	(%)	
Quebec			
Dumont Nickel Corporation, Launey Township	15,500,000	Ni(0.646)	Negotiations to raise capital for 4,500-tpd operation. Investigating process to recover nickel on site.
Expo Ungava Mines Limited, Ungava	18,500,000	Ni(0.47) Cu(0.52)	
New Quebec Raglan Mines Limited, Ungava	16,050,000	Ni(2.58) Cu(0.71)	Feasibility and engineering studies.
Ontario			
Great Lakes Nickel Limited, Pardee Township	106,000,000	Ni(0.20) Cu(0.40)	Under agreement with Boliden Aktiebolag. Underground exploration and metallurgical studies completed. Feasibility study to bring property to production at 1.8 million tpy.
The International Nickel Company of Canada, Limited, Sudbury, Cryderman, North Range, Victoria, and Whistle mines	..	Ni(. .) Cu(. .)	
Union Minière Explorations and Mining Corporation Limited, Pickle Crow, Thierry deposit	10,000,000	Ni(0.2) Cu(1.6)	Exploration shaft in progress. Road completed into property.
Manitoba			
Bowden Lake Nickel Mines Limited, Wabowden,			
Bowden Lake mine	80,000,000	Ni(0.60)	
Bucko Lake mine	30,000,000	Ni(0.78)	Underground exploration in 1972. Feasibility study.
Saskatchewan			
National Nickel Ltd. and Cadillac Explorations Limited, Nemeiben Lake, La Ronge	5,476,000	Ni(0.34) Cu(0.18)	Open pit reserves.
	1,754,500	Ni(0.38) Cu(0.70)	Underground reserves.

Sources: Corporate annual reports and technical press.
. . Not available.

Ore treatment has increased to 240 tons a day and the company is optimistic that it can be raised to 250-300 tons. Somex concentrates are shipped to the Sherritt Gordon Fort Saskatchewan refinery for further treatment.

Consolidated Canadian Faraday Limited closed its

Werner Lake mine in August 1972 when ore reserves were depleted. However, the mill and concentrator continue to treat ore from the Dumbarton Mines Limited Bird River mine. Dumbarton increased daily ore production from 800 to 1,100 tons to compensate for the mine closure at Werner Lake. Before the mine closed, Consolidated Canadian Faraday concentrates were shipped to Inco's Sudbury smelter; Dumbarton concentrate is treated at the Falconbridge smelter.

Texmont Mines Limited, which placed its Timmins area, Ontario, mine into production in 1971, continued to produce a nickel concentrate until November 1972. Most of Texmont's concentrate is held in a stockpile. A hydrometallurgical reduction facility, used to refine some of the stockpiled concentrate, is located on the property. Negotiations for the sale of mine output are in progress.

In British Columbia, Giant Mascot Mines Limited has gradually increased its daily milling rate to 1,825 tons. Mill throughput before the 1970 fire, which destroyed most of the surface buildings, was 1,500 tons. The company has obtained an extension of its labour contract to June 30, 1974. Formerly, Giant Mascot sold a bulk nickel-copper concentrate in Japan but in February 1973, this contract was terminated. The company is now making separate nickel and copper concentrates and selling nickel concentrate to Sherritt Gordon under a five-year contract and copper concentrate to Japan.

The Wellgreen mine, operated by Hudson-Yukon Mining Co., Limited and located at Kluane Lake, Yukon Territory, was commissioned in May 1972. All production, consisting of a bulk nickel-copper concentrate, is sold in Japan. As a result of recent underground exploration and development work, which identified unforeseen irregularities in the orebody, Hudson-Yukon has announced that the mine is not economical to operate and will be closed in 1973.

Two companies have announced they are opening new mines in 1973. Noranda Mines Limited has scheduled a mid-1973 production date for its 700-ton-a-day Langmuir mine, located near Timmins, Ontario. The concentrator, service buildings and shaft were completed in 1972. Langmuir mine is jointly owned by Noranda and Inco. In the Temagami area of Ontario, Kanichee Mining Incorporated is developing a small open pit nickel-copper deposit for mid-1973 production. A mill and concentrator, with daily capacity of 500 tons, is being erected on the property. Kanichee will produce a bulk nickel-copper concentrate.

Under an agreement with Great Lakes Nickel Limited, Boliden Aktiebolag has concluded a major development program on the Great Lakes nickel-copper orebody. The Great Lakes property is located near Thunder Bay in northwestern Ontario. During 1972, a 1,700-foot tunnel, surface and underground drilling and mining of a 2,300-ton bulk sample were completed. The ore sample was shipped to Boliden, Sweden, for pilot plant testing. Boliden has recommended, on the basis of encouraging development and feasibility results, a mining complex with an annual capacity of 1.8 million tons of ore. The proposal recommends the production of separate copper and nickel concentrates for, initially, offshore processing.

Union Minière Explorations and Mining Corporation Limited (Umex) continued underground exploration work on its nickel-copper Thierry deposit, near Pickle Crow, Ontario. Shaft sinking, road construction and electrical services installation were under way in 1972. At the Bowden Lake Nickel Mines Limited property near Wabowden, Manitoba, an underground exploration program was in progress. This project includes shaft sinking, lateral excavating and diamond drilling on the Bucko Lake deposit. Work to date indicates that there may be higher-grade sections of the deposit that could be selectively mined.

World developments

World mine production of nickel decreased from 737,852 tons in 1971 to an estimated 676,895 tons in 1972. The dominant factors which led to the lower output were the voluntary reductions of mine production in Canada and New Caledonia and the suspension of ore shipments for about two months from New Caledonia to Japan. New Caledonia producers suspended ore shipments pending a new agreement on prices. By year-end, these shipments were resumed, following an upward adjustment in price to reflect the new price structure for refined nickel.

The Dominican Republic joined the ranks of major producer countries in 1972. Falconbridge Dominicana C. Por A. completed its first year of ferronickel production from laterite ore and expects to attain capacity output on a continuous basis in 1973. The complex has a designed annual capacity of 31,500 tons of nickel contained in ferronickel.

Increasing concern for the shortage of nickel during the 1960's, higher nickel prices and the heavy dependence on Canadian sources for supplies have contributed to growing activity in other countries to bring nickel deposits, largely of garnierite and laterite types, into production. More recently, however, as a result of softening nickel markets, most hopeful producers have re-evaluated their projects and some have curtailed their plans while others have announced delays and deferments. Three major projects are in an advanced stage of development.

In Botswana, Bamangwato Concessions Ltd. is preparing its Pikwe nickel-copper sulphide mine and flash smelter for early 1974 production. Nickel-copper matte from the smelter is to be toll-refined at the American Metal Climax, Inc. Port Nickel refinery in Braithwaite, Louisiana, U.S.A. Annual output from the Pikwe project is being scheduled at 18,700 tons of contained nickel, 17,000 tons of contained copper and 127,000 tons of sulphur. The modernized Port Nickel refinery, which is designed to have an annual capacity

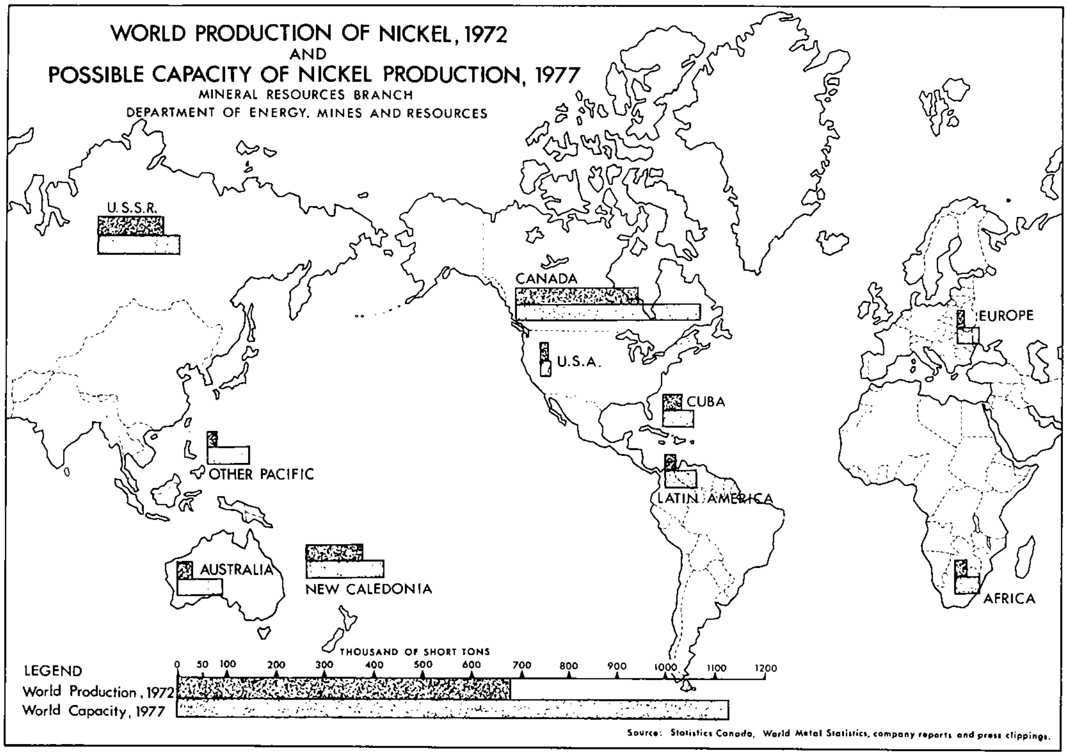


Table 6. World production of nickel, 1971-72

	1971	1972[e]
Canada[1]	294,341	258,087
New Caledonia	153,110	110,341
U.S.S.R.	132,277	135,000
Cuba	38,580	39,683
Australia	34,282	31,300
United States	17,036	17,000
Indonesia	13,220	13,227
Republic of South Africa	14,110	12,897
Greece	11,795	7,700
Finland	3,968	5,732
Rhodesia	12,787	13,300
Brazil	3,086	3,968
Poland	2,205	2,205
Other countries	7,055	26,455
Total	737,852	676,895

Sources: World Metal Statistics, March 1973. For Canada, Statistics Canada.
[1]Production all forms.
[e]Estimated.

of 40,000 tons of nickel, will produce nickel powder and briquettes, copper powder, briquettes and wire-bar, and other associated byproducts. Marinduque Mining and Industrial Corporation, in which Sherritt Gordon Mines, Limited has a 10 per cent interest, is proceeding with construction of its nickel complex in the Philippines. This will be the first commercial plant to use the Sherritt Gordon nickel laterite process. Design capacity at the Philippine project is 34,200 tons of nickel powder and briquettes, 3,300 tons of nickel in mixed sulphides and 1,650 tons of cobalt. Start-up has been scheduled for the third quarter of 1974. Construction at the Australian Greenvale project, owned by Freeport Mineral Company and Metals Exploration N.L., is under way and commercial mining is expected by late 1974. Lateritic ore from Greenvale is to be railed to the company's refining facilities in Townsville, where annual capacity has been planned for 27,000 tons of nickel contained in nickel oxide sinter and mixed sulphides.

The International Nickel Company of Canada, Limited has two foreign laterite projects that the company is planning to place in production during the second half of the decade. One of these, P.T. International Nickel Indonesia, has announced a

Table 7. Prospective world nickel producers[1]

Country Company Mine	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tons of contained nickel)			
Australia				
Anaconda Australia Inc., Conzinc Riotinto of Australia Limited, N.B.H.C. Holdings Limited, Redross mine, Widgiemooltha	5,000	1974	Kalgoorlie	Sherritt Gordon has 5-year agreement to purchase all concentrates.
Freeport Minerals Company and Metals Exploration N.L., Greenvale deposit, Queensland	27,000	1974	Own refinery	Refinery to be built at Townsville.
Freeport Minerals Company, Australian Consolidated Minerals, N.L., and Metals Exploration N.L., Mt. Keith, Western Australia	..	..	..	Original proposal called for production in 1975.
Poseidon N.L. and Western Mining Corporation (WMC), Windarra, Western Australia	12,000	1974	WMC smelter	Sherritt Gordon to purchase half of output.
Selection Trust Limited, Spargoville, Western Australia	6,000	1972	Kalgoorlie	Production from No. 2 location began in 1972; from No. 3 in 1973.
Botswana				
Bamangwato Concessions Ltd., Selebi-Pikwe	18,700	1973	Port Nickel, Louisiana, U.S.A.	
Brazil				
Cia Niquel Tocatins	5,500	1975	Own plant	
Colombia				
The Hanna Mining Company, Compania Niquel Chevron and Industrial Development Institute of Colombia, Cerro Matoso, Cordoba	18,750	1975-76	Own smelter	Re-evaluation.
Cuba				
Punta Gorda deposit	30,000	1975	Own plant	Plant to be expanded to 54,000 by 1985.
Greece				
Intercontinental Mining and Abrasives, Inc. and Southland Mining Company, Evia mine, Lake Ionina	9,000	1974	Own smelter	

Table 7 (cont'd)

Country Company Mine	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tons of contained nickel)			
Greece (cont.)				
Intercontinental Mining and Abrasives, Inc., Athens	6,000	1974	–	Smelter only. Ore to be supplied by other mining companies.
Scalistiris Group, Eubeoa Island	. .	1975	Own plant	Pilot plant built.
Guatemala				
Exploraciones y Explotaciones Mineras Izabal, S.A. (EXMIBAL), Lake Izabal	14,000	. .	. .	Production possible 3 years after construction begins.
India				
Hindustan Copper Ltd., Onissa State	5,300	1976	Own plant	Refinery to produce nickel powder.
Indonesia				
P.T. Aneka Tambang, Pomalea, Sulawesi	4,000	1974	Own smelter	Ferronickel plant.
P.T. International Nickel Indonesia, Malili, Sulawesi	15,000	1976	Own smelter	Plans to expand to 50,000 tpy.
P.T. Pacific Nikkel Indonesia, Waigeo area, Irian Barat	25,000	. .	Own smelter	12,000 tons ore shipped to Sherritt Gordon Mines Limited for test treatment in 1972.
Sulawesi Nickel Development Cooperation Company (SUNIDECO), Pomalea, Sulawesi	13,200	. .	Own smelter	To produce ferronickel for export to Japan.
New Caledonia				
The International Nickel Company of Canada, Limited, Goro deposit	22,500	. .	Own refinery	Plans to expand to 110,000 tpy. Could be in production in 1977.
Patino, N.V., Pechiney Ugine Kuhlmann Development, Inc. and Gränges AB, Poum	. .	. .	Own smelter	Site selection and financial arrangements in progress.
Société Nationale des Pétroles d'Aquitaine and Freeport Minerals Company	25,000	. .	Own smelter	

Table 7 (concl'd)

Country Company Mine	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tons of contained nickel)			
New Caledonia (cont.)				
Société Minière et Métallurgique de Penarroya, S.A. and American Metal Climax, Inc. (PENAMAX)	25,000	..	Port Nickel, Louisiana, U.S.A.	
Republic of the Philippines				
Marinduque Mining and Industrial Corporation, Nonoc Island	37,500	1974	Own refinery	Constructing Sherritt Gordon-type refinery.
Rio Tuba Nickel Mining, Palawan Island	20,000	1976	Japan	Annual shipments of 1 million tons of garnierite ore.
Rhodesia				
Johannesburg Consolidated Investment Company, Shangani mine	4,500	1976	Own smelter	
Venezuela				
Société le Nickel and Venezuelan Government, Loma de Hierro	22,000	..	Own smelter	Congressional approval required.
Yugoslavia				
Government company	13,000	1976	Own smelter	Plan to produce 48,500 tpy of ferronickel.

Sources: Company annual reports and technical press.
[1]Companies which have announced probable production dates. . . No information.

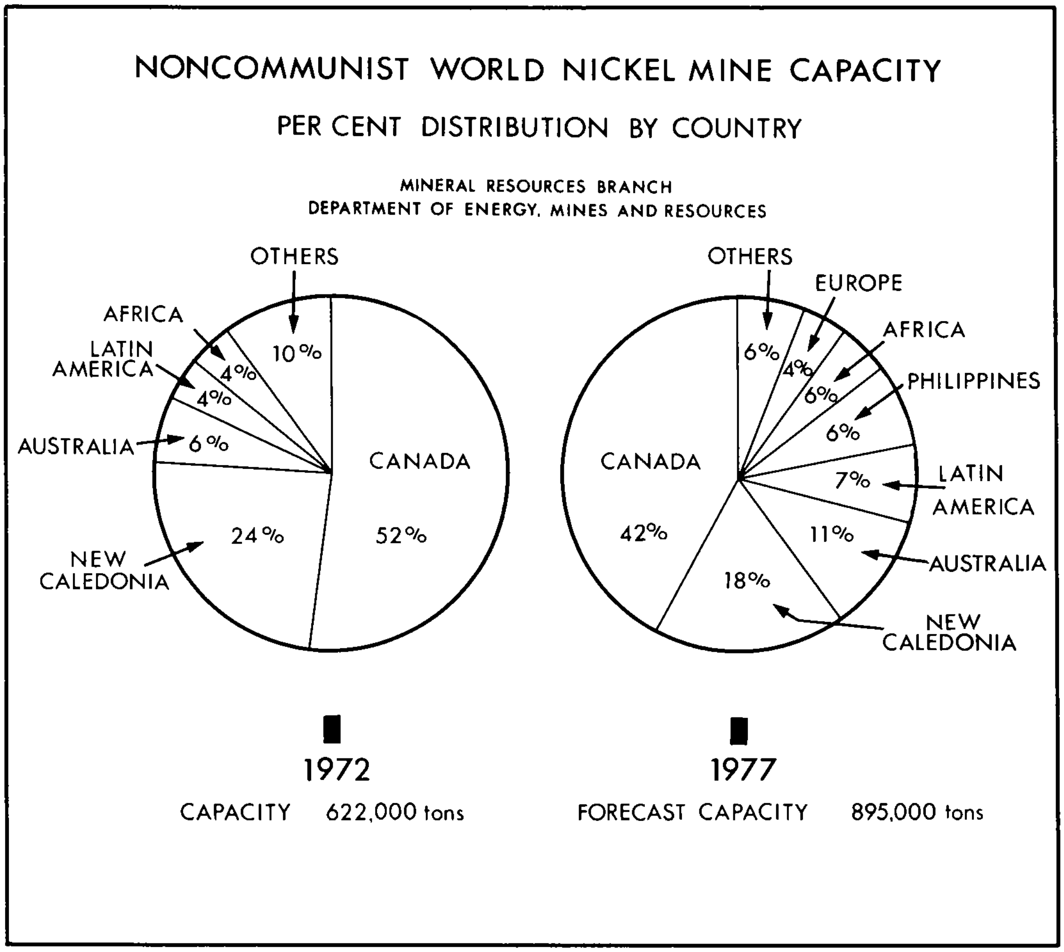
Table 8. Noncommunist world mine nickel production capacity

	1972	1973	1974	1975	1976	1977
	(thousands of short tons)					
Canada	325	325	335	360	375	375
New Caledonia	150	150	150	150	150	160
Australia	40	42	50	72	85	95
Latin America	27	37	38	38	50	65
Philippines	3	3	13	23	50	55
Africa	27	33	40	43	45	50
Europe	15	20	28	30	35	40
Indonesia	18	18	18	20	27	35
United States	17	18	18	19	19	20
Total	622	646	690	755	836	895

Sources: Company reports and technical press.

schedule to develop the Malii-Soroako deposits on Sulawesi, Indonesia. The company intends to ship all of the Indonesia output, some 15,000 tons of nickel a year contained in matte, to Japanese refineries. Initial deliveries are expected during the first half of 1976. In Guatemala, Inco, through Exploraciones y Explotaciones Mineras Izabal, S. A. (EXMIBAL) was nearing the end of negotiations with the Guatemalan government to develop the Lake Izabal laterite deposit. More recent announcements indicate that financing for the complex is well advanced. Inco has proposed a multiphase development that will initially have an annual capacity of 14,000 tons of contained nickel.

Two new sulphide mines have been slated for production in Western Australia. The Redross mine is being prepared for mining in late 1974. Ore will be toll-milled at Kalgoorlie and concentrate is to be shipped to Sherritt Gordon's refinery in Canada.



Initial annual production will provide 5,000 tons of nickel. Poseidon N.L. has terminated its agreement with Union Oil Company of California, Homestake Mining Company and The Hanna Mining Company and has entered a joint venture with Western Mining Corporation Limited to develop its Windarra orebody. The revised program calls for annual production of 12,000 tons of nickel to begin in late 1974. Western Mining will smelt the Windarra concentrate and half of the resulting matte will be purchased by Sherritt Gordon. Western Mining commissioned its new flash smelter, reported to have an annual capacity of 200,000 tons of concentrate, in December 1972. Although Selection Trust Limited has not announced a production schedule for its Agnew deposit, development will likely begin soon. Ore reserves are currently reported at 33 million tons of about 2 per cent nickel.

Société le Nickel has expanded production facilities in New Caledonia and now has an installed annual smelter capacity of some 77,000 tons of nickel. However, production has been held below this level because of the weak nickel markets. Other projects in New Caledonia are taking form very slowly and their start-up dates are uncertain at this stage.

Cuba has announced plans to renovate the Moa Bay and Nicaro refineries, thereby assuring a continuing supply of about 40,000 tons of Cuban nickel each year, and development of the Punta Gorda orebody in the near future. The latter will add some 30,000 tons of nickel a year to Cuban production. U.S.S.R. and COMECON countries are to provide financing for the Cuban expansion.

Although many laterite projects have been curtailed or deferred, several companies are still proceeding with plans to develop a large production capacity over the next five years. If all of the planned projects are brought to production on their scheduled start-up dates, the industry will undoubtedly face a long period of nickel oversupply.

Uses

Nickel uses have not changed appreciably from the traditional pattern. Resistance to corrosion, high strength over a wide temperature range, pleasing appearance and suitability as an alloying agent are the chief advantages in almost all the uses of nickel.

Stainless steel is the largest single outlet for nickel, followed by nickel plating and high-nickel alloys. Stainless steel use has increased in the field of rapid transit and railway car manufacture, in fertilizer and food processing machinery, in petroleum refining and in architectural applications. High-nickel alloys are used in chemical, marine, electronic, nuclear and aerospace applications.

New end-use markets which will contribute to nickel's consumption growth are gas turbine engines for surface applications, cryogenic containers, nuclear generating plants and pollution abatement equipment.

Outlook

The nickel market is expected to strengthen throughout 1973 as the economies of major world nations continue to improve. Noncommunist world consumption should exceed the record 1970 level of 975 million pounds. Unfortunately, this growth in demand is unlikely to have any significant effect upon Canadian production during 1973. Canadian producers will use their surplus inventories to supplement output before reactivating idle capacity. Operations that were temporarily suspended in 1971 and 1972 are unlikely to resume production before 1974.

The medium-term outlook is for steady growth in nickel consumption, at a compound rate of 6 to 7 per cent a year. New nickel projects scheduled for production in the next three years are more than adequate to meet medium-term demand and there should be ample supplies of nickel during the seventies.

With the widespread acceptance of the argon-oxygen furnace in stainless steel making, less pure forms of nickel, such as ferronickel, should be consumed at an increasing rate, partly at the expense of high-purity nickel and nickel oxide sinter. Intense marketing competition can be expected for most forms of nickel and should be particularly noticeable in the stainless steel market over the next several years.

Prices

Producers' prices remained unchanged during the first half of 1972 although there was some discounting by small foreign operators. During September, the price of electrolytic nickel was raised by U.S. 20 cents a pound to U.S.$1.53. The previous producers' price increase took effect in October 1970 when the refined metal was raised from U.S.$1.28 to U.S.$1.33 a pound. New prices were also announced for Class II forms of nickel but the posted increases were not proportionately as large as those for Class I forms. The substantial price differential which now exists between the two classes of nickel is an indication of the more intense competition that has developed in the market for Class II nickel.

For most sales, the new price structure will not take effect until 1973. Furthermore, it has been reported that some shipments of Class II product will be delivered at the old price level until mid-1973.

Many companies stated that the increases were in response to higher operating and capital costs, lower ore grades being mined and revaluation of local currencies vis-à-vis the U.S. dollar.

Producer prices for nickel quoted during 1972

	Canada		United States	
	Jan.-Sept.	Sept.-Dec.	Jan.-Sept.	Sept.-Dec
	(cents per pound)			
Falconbridge Nickel				
Electrolytic, fob Thorold, Ont., 10,000 lb lots	137.5	*	133	153
Granular nickel 98	*	*	131.5	151.5
Ferronickel[1]	–	–	129	139
Inco				
Electrolytic, fob Port Colborne, Ont.	137.5	*	133	153
Nickel oxide sinter[1]				
'90'	132	*	128	140

Inco (concl'd)

'75'	131	*	127	137
F shot[1]	–	–	136	143
Pellets	–	–	135	155
Sherritt Gordon				
Briquettes or powder, fob Niagara Falls, Ont. and Fort Saskatchewan, Alta. 20,000 lb lots	*	*	133	153
The Hanna Mining Company				
Ferronickel[1]	–	–	130.5-128	138
Kaiser Aluminum & Chemical Corporation				
Ferronickel, fob Baltimore, Md., U.S.A.				
KFN-3	–	–	130	142
KFN-4	–	–	128	137
Société le Nickel				
Rondelles	–	–	131.5	151.5
Ferronickel[1]				
FN1	–	–	133	150
FN3	–	–	130	145
FN4	–	–	128	140
Western Mining Corporation Limited				
Briquettes or powder	–	–	133	153

Sources: *The Northern Miner, Metals Week, American Metal Market* and *Metal Bulletin.*
[1]Price applies to nickel content. *Canadian price is based on U.S. price converted to Canadian funds by official exchange rate.
– Not quoted.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
35500-1	Nickel, and alloys containing 60% or more nickel by weight, not otherwise provided for, viz: ingots, blocks and shot; shapes or section, billets, bars and rods, rolled extruded or drawn (not including nickel processed for use as anodes) strip, sheet and plate (polished or not); seamless tube	free	free	free
32900-1	Nickel ores	free	free	free
33506-1	Nickelous oxide	10	15	25
35505-1	Rods, containing 90% or more nickel, when imported by manufacturers of nickel electrode wire for spark plugs, for use exclusively in manufacture of such wire for spark plugs in their own factories	free	free	10
35510-1	Metal, alloy strip or tubing, not being steel strip or tubing, containing not less than 30% by weight of nickel and 12% by weight of chromium, for use in Canadian manufactures	free	free	20

Tariffs (concl'd)

35800-1	Anodes of nickel	free	free	10
35515-1	Nickel, and alloys containing 60% by weight or more of nickel, in powder form	free	free	free
35520-1	Nickel or nickel alloys, namely: matte sludges, spent catalysts and scrap, and concentrates other than ores	free	free	free
44643-1	Articles of iron, steel or nickel, or of which iron, steel or nickel are the component materials of chief value, of a class or kind not made in Canada, when imported by manufacturers of electric storage batteries for use exclusively in manufacture of such storage batteries, in own factories	10	10	20
37506-1	Ferronickel	free	5	5

United States

Item No.				
601.36	Nickel ore	free		
603.60	Nickel matte	free		
620.03	Nickel, unwrought	free		
		On and After January 1		
		1970	1971	1972
		(¢ per pound)		
620.04	Nickel waste and scrap (duty suspended on or before June 30, 1973)	0.5	0.2	free
620.30	Nickel flakes	7	6	5
620.32	Nickel powders	free	free	free
620.50	Nickel electroplating anodes, wrought and cast, of nickel	7%	6%	5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. United States, Tariff Schedules of the United States Annotated (1972), TC Publication 452.

Petroleum

W.G. LUGG

Some of the events which occurred in Canada's oil and gas industry during 1972 are likely to strongly influence the direction of its future growth. Exploration in the frontier areas is increasing and was rewarded by several more oil and gas discoveries in 1972. In the Arctic islands, Panarctic Oils Ltd., the industry-government company, continued their successful exploratory program and recorded their first oil discovery on Ellesmere Island. Several more oil and gas discoveries were made in the Mackenzie Delta and another gas-condensate discovery was drilled on the eastern seaboard near Sable Island. Preliminary reports suggest that some of these are major discoveries and providing operational problems can be overcome, will eventually alter Canada's existing supply patterns.

Record production levels and increased prices raised the value of oil and gas production to an all-time high of $2.1 billion. Expenditures by the industry increased by $100 million over that of 1971 to $1.8 billion in 1972; much of this increase was again due to the high costs of exploring for oil and gas in northern and offshore areas.

On the international scene and of importance to the worldwide industry, four Persian Gulf members of the Organization of Petroleum Exporting Countries (OPEC) reached agreement with the international oil companies operating within their boundaries for the transfer of part ownership of their operations. Under the terms of this precedent-setting agreement effective January 1, 1973, Saudi Arabia, Quatar, Abu Dhabi and Kuwait acquired a 25 per cent ownership. In 1978, the ownership interest is scheduled to be raised by 5 per cent a year to a maximum of 51 per cent on January 1, 1982.

The limited potential for producing and refining more crude oil in the United States, combined with year-end shortages of products precipitated by prolonged cold weather, was responsible for record exports of Canadian crude oil and petroleum products. As a result, the problem of excess productive capacity which has long plagued the Canadian producing industry was virtually eliminated in 1972.

Refinery expansion slackened in 1972 following the record growth rate in the previous year. No new refineries were built. However, two major refineries are now under construction – one in Newfoundland scheduled for completion in 1973 and the other in Edmonton with a completion date of 1974. Other large plants, to be located in the Maritime Provinces and designed to serve the export market are currently in the planning stage with construction dates still pending. Oil pipeline construction also lagged in 1972, but recently announced expansion programs by major trunk carriers assures a significant increase in the coming year.

Production

Net Canadian production of all liquid hydrocarbons – crude oil and natural gas liquids – increased 16.1 per cent in 1972 to 671 million barrels. Crude oil output alone amounted to 562 million barrels or 1,540,000 barrels daily and field and gas plant production of natural gas liquids totalled 109 million barrels or 299,000 b/d. Crude oil production declined in all provinces except Alberta, which exceeded last year's production by 19.5 per cent. Alberta production at 1,219,000 b/d accounted for 79 per cent of the total Canadian crude oil output in 1972 and of this amount, synthetic crude oil production from the Great Canadian Oil Sands Limited's plant at Fort McMurray contributed 51,000 b/d. Saskatchewan contributed 237,000 b/d, which was 15.4 per cent of total Canadian production but 4,000 b/d less than in 1971. British Columbia's production at 65,000 b/d represented 4.2 per cent of the national total, but 4,000 b/d lower than output during the previous year. The remaining 1.4 per cent was provided by Manitoba, Ontario, the Northwest Territories and New Brunswick. All provinces except Alberta were producing near capacity. The Alberta Energy Resources Conservation Board (AERCB) estimated that the 1971 adjusted wellhead capacity was 1.65 million b/d, which meant that about 74 per cent of the province's capability was being utilized at the end of 1972. Since 1968, Alberta's unused productive capacity has declined from 56 per cent of the then current production rate to 26 per cent in 1972.

Early in 1973, Great Canadian Oil Sands Limited (GCOS) applied to the AERCB to increase its allowable production of synthetic crude oil to 65,000 b/d from its present allowable rate of 45,000 b/d. The Great Canadian Oil Sands recovery plant is located near Fort McMurray and, as previously stated, averaged 51,000 b/d during 1972, compared with 40,500 b/d in 1971. The plant has sustained higher than authorized production levels for almost a year to make up for

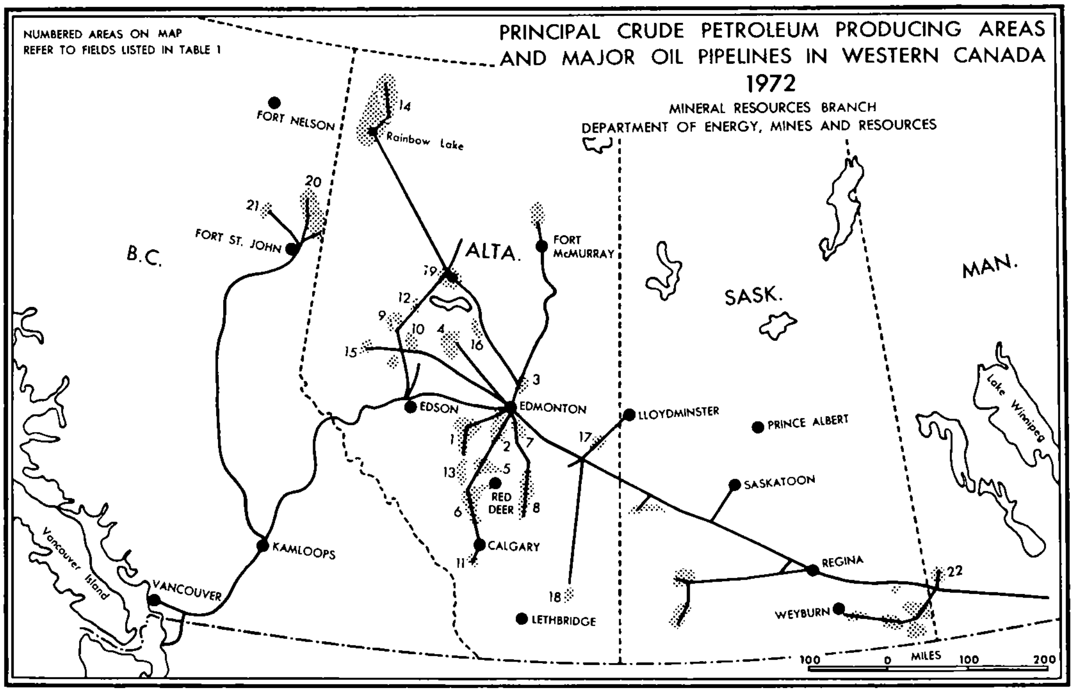


Table 1. Production of crude oil and condensate by province and field, 1971-72

(Number in parenthesis gives location of field on accompanying map.)

	1971		1972^{p}	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Alberta				
Pembina (1)	53,872,369	147,596	50,680,729	138,851
Swan Hills (4)	32,975,072	90,343	38,478,226	105,420
Redwater (3)	23,077,286	63,225	31,420,047	86,082
Rainbow (14)	24,185,186	66,261	29,380,584	80,495
Judy Creek	17,702,358	48,500	22,571,208	61,839
Bonnie Glen (2)	14,328,615	39,256	18,718,954	51,285
Swan Hills South (4)	14,334,794	39,273	17,667,206	48,403
Wizard Lake (2)	11,547,117	31,636	17,482,568	47,897
Mitsue (16)	13,504,248	36,998	15,480,751	42,413
Nipisi (19)	10,740,108	29,425	14,800,762	40,550
Golden Spike (2)	11,994,551	32,862	13,159,318	36,053
Fenn Big Valley (8)	7,769,951	21,288	9,926,906	27,197
Leduc Woodbend (2)	6,228,327	17,064	7,453,623	20,421
Carson Creek North (4)	5,242,678	14,364	6,996,730	19,169
Zama (14)	4,095,681	11,221	5,924,888	16,233
Sturgeon Lake South	4,507,375	12,349	5,724,469	15,683
Westerose (2)	3,231,017	8,852	5,588,629	15,311
Willisdan Green (13)	5,093,679	13,955	5,520,209	15,124
Kaybob (10)	4,410,848	12,085	5,181,156	14,195

Table 1 (cont'd)

	1971		1972[p]	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Acheson (2)	3,620,791	9,920	4,243,502	11,626
Harmattan East (6)	2,672,928	7,323	3,274,400	8,971
Joffre (5)	2,588,423	7,092	3,168,864	8,682
Virgo (14)	2,574,232	7,053	3,160,251	8,658
Snipe Lake	2,827,630	7,747	3,148,130	8,625
Kaybob South (10)	2,521,979	6,910	3,136,215	8,592
Simonette (15)	1,552,384	4,253	3,026,657	8,292
Rainbow South (14)	3,172,882	8,693	2,938,790	8,051
Innisfail (6)	2,383,100	6,529	2,938,123	8,050
Joarcam (7)	2,348,232	6,434	2,804,369	7,683
Medicine River (13)	2,090,663	5,728	2,547,827	6,980
Clive	2,326,404	6,374	2,473,196	6,776
Wainwright (17)	2,402,600	6,582	2,427,875	6,652
Countess	1,065,457	2,919	2,406,433	6,592
Provost	1,967,032	5,389	2,389,391	6,546
Goose River	1,938,208	5,310	2,332,087	6,389
Harmattan Elkton (6)	1,777,909	4,871	2,321,189	6,359
Gilby (5)	1,761,096	4,825	2,178,930	5,970
Bantry (18)	2,376,645	6,511	2,086,656	5,717
Bellshill Lake	1,735,739	4,755	2,003,357	5,489
Stettler	1,258,183	3,447	1,606,624	4,401
Grand Forks	539,696	1,479	1,500,040	4,110
Ferrier	1,178,221	3,228	1,283,668	3,517
Sundre	1,132,326	3,102	1,274,010	3,490
Sylvan Lake	1,038,074	2,844	1,180,885	3,235
Taber South	1,356,414	3,716	1,149,252	3,149
Cessford	1,018,990	2,792	1,067,651	2,925
Hussar	885,261	2,425	1,058,628	2,900
West Drumheller	817,004	2,238	1,028,642	2,818
Turner Valley (11)	1,069,745	2,931	1,012,308	2,773
Other fields and pools	46,661,414	127,839	55,659,191	152,491
Total	371,500,922	1,017,811	444,984,104	1,219,135
Total value ($)	1,055,769,236		1,272,343,049	
Saskatchewan[1]				
Total	88,458,641	242,352	86,599,428	237,259
Total value ($)	217,828,519		218,230,559	
British Columbia				
Boundary Lake (20)	9,703,989	26,586	9,426,811	25,827
Peejay (20)	4,425,895	12,126	3,789,160	10,381
Inga (21)	3,269,940	8,959	3,693,241	10,118
Milligan Creek (20)	3,152,309	8,636	2,443,156	6,694
Other	4,710,997	12,907	4,482,834	12,282
Total	25,263,130	69,485	23,835,202	65,302
Total value ($)	63,983,930		63,044,109	
Manitoba				
North Virden Scallion (22)	2,775,062	7,603	2,619,531	7,177
Virden-Roselea (22)	1,388,623	3,804	1,345,361	3,686
Other fields	1,440,886	3,948	1,292,047	3,540
Total	5,604,571	15,355	5,256,939	14,403
Total value ($)	15,412,570		14,509,152	

Table 1 (concl'd)

	1971		1972^p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Ontario				
Total	958,104	2,625	878,065	2,406
Total value ($)	2,726,771		2,503,890	
Northwest Territories				
Total	944,083	2,587	890,067	2,439
Total value ($)	1,208,426		1,156,998	
New Brunswick				
Total	9,598	26	8,714	24
Total value ($)	13,437		12,587	
Canada				
Total	492,739,049	1,349,970	562,452,519	1,540,875
Total value ($)	1,356,942,889		1,571,800,344	

Source: Provincial government reports and Statistics Canada.
[1] Saskatchewan lists production by formation rather than by field.
^{p}Preliminary.

Table 2. Production of natural gas liquids by province, 1971-72

	1971		1972^p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Alberta				
Propane	23,133,202	63,379	29,186,910	79,964
Butane	15,115,654	41,413	19,105,038	52,343
Pentanes plus	44,500,100	121,918	58,183,059	159,406
Condensate	783,881	2,148	968,647	2,654
Total	83,532,837	228,857	107,443,654	294,366
Saskatchewan				
Propane	797,366	2,185	764,141	2,094
Butane	373,510	1,023	320,124	877
Pentanes plus	391,008	1,071	400,159	1,096
Total	1,561,884	4,279	1,484,424	4,066
British Columbia				
Propane	468,876	1,285	480,047	1,315
Butane	318,195	872	340,904	934
Pentanes plus	1,114,139	3,052	1,018,102	2,789
Condensate	109,008	299	104,531	286
Total	2,010,218	5,507	1,943,584	5,325

Table 2 (concl'd)

	1971		1972^p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Canada				
Propane	24,399,444	66,848	30,431,098	83,373
Butane	15,807,359	43,308	19,766,066	54,154
Pentanes plus	46,005,247	126,042	59,601,320	163,291
Condensate	892,889	2,446	1,073,178	2,940
Total	87,104,939	238,643	110,871,662	302,772
Returned to formation	542,681	1,487	1,275,590	3,495
Total net production	86,562,258	237,156	109,596,072	300,263

Source: Provincial government reports.
^{p}Preliminary.

past low production rates. A decision on Great Canadian's application was pending at year-end.

Late in 1972 the Alberta government announced its intention to formulate a new oil sands development policy in 1973 and to deal with many problem areas, including royalty, production and operational schedules and the potential economic impact. However, early in 1973, Alberta decided not to establish a long-term policy for oil sands development in the immediate future, but rather to give first priority to getting a second tar sands plant under way. At about the same time, Syncrude Canada Ltd. asked the AERCB for deferment from January 1, 1977 to January 1, 1978 of the stipulated date of start-up of its proposed plant near Fort McMurray. Estimated capital cost of the plant has been revised upward from $650 million to $744 million. Syncrude Canada Ltd. is jointly owned by Altantic Richfield Canada Ltd., Canada-Cities Service, Ltd., Imperial Oil Limited and Gulf Oil Canada Limited. Syncrude's present scheme calls for the construction of a plant to produce 125,000 b/d of synthetic crude oil and 5,500 b/d of residual fuel oil. Both the GCOS plant and the proposed Syncrude project utilize surface mining methods. Since the bulk of the sands are buried too deep for this type of recovery method, several operators, including Shell Canada Limited and Amoco Canada Petroleum Company Ltd. plan on using in situ thermal methods to produce the oil from the formation.

Table 3. Value of natural gas liquids by province, 1971-72

	1971	1972^p
	($ thousand)	
Alberta	186,339	238,801
Saskatchewan	2,844	2,829
British Columbia	4,008	3,782
Total, Canada	193,191	245,412
Volume (thousand bbl)	85,678	106,947

Source: Statistics Canada.
^{p}Preliminary.

Reserves

In the face of record production levels, Canada's liquid hydrocarbon reserves, which include conventional crude oil and natural gas liquids, declined for the third consecutive year. Estimating production of crude oil and natural gas liquids at 621 million barrels in 1972, the Canadian Petroleum Association (CPA) calculated that proved remaining reserves had declined by 439 million barrels to a year-end total of 9,723 million barrels. This is comprised of 8,020 million barrels of crude oil and 1,703 million barrels of natural gas liquids. Reserves added in 1972 totalled 182 million barrels and of this amount 110 million barrels were attributable to revisions, 45 million barrels to extensions of established fields and 27 million barrels to new discoveries. Using the 1972 level of production, the life index for conventional crude oil and natural gas liquids dropped to 15.6 years, the lowest it has been since the discovery of the Leduc field and the birth of the modern Canadian oil industry

Table 4. Canada, crude oil production, trade and refinery receipts, 1962-72

	Production[1]	Imports[2]	Exports[2]	Refinery Receipts[3] Domestic	Refinery Receipts[3] Imports	Refinery Receipts[3] Totals
			(barrels)			
1962	244,115,152	134,517,707	91,580,232	173,606,596	135,364,821	308,971,417
1963	257,661,777	147,720,870	90,875,816	186,157,830	146,586,964	332,744,794
1964	274,626,385	143,530,957	101,258,926	199,456,597	143,946,481	343,403,078
1965	296,418,914	144,184,281	108,010,297	208,581,343	144,000,656	352,581,999
1966	320,542,794	146,076,898	123,691,342	220,196,625	158,546,823	378,743,448
1967	351,292,332	170,784,980	150,344,567	224,569,817	163,148,797	387,718,614
1968	379,396,276	177,738,586	167,487,968	236,178,376	177,293,134	413,471,510
1969	410,989,930	193,124,846	197,340,741	242,034,744	190,479,081	432,513,825
1970	461,180,059	207,633,062	240,893,633	258,966,344	208,339,853	467,306,197
1971	492,739,049	244,971,778	270,770,498	263,239,168	244,224,822	507,463,990
1972[p]	562,452,519	281,664,159	341,252,881	273,287,307	288,754,232	562,041,539

Source: Statistics Canada.
[1]Alberta field condensate excluded from statistics for 1962. [2]Trade of Canada (SC) data. [3]Include condensate and pentanes plus.
[p]Preliminary.

Reserves in all western provinces declined, the largest reduction occurred in Alberta where total reserves decreased by 247 million barrels. The CPA estimated Alberta's remaining recoverable reserves of crude oil at 7,103 million barrels and natural gas liquids at 1,655 million barrels. Together this accounted for about 90 per cent of Canada's proven reserves. Almost all of the additions to reserves in Alberta in 1972 were again due to revisions and extensions of existing fields. Only 22 million barrels were credited to new discoveries. Both British Columbia and Saskatchewan also showed a significant decline in proven reserves. Although not large in relation to national totals, Ontario more than doubled its proven reserves mainly through the introduction of several new secondary recovery schemes, but with some contribution from new discoveries. The CPA reserve estimates do not include reserves recently discovered in northern Canada and Atlantic offshore regions. Unofficial estimates by industry officials place the minimum reserve base required to economically justify building a pipeline to southern markets from the Mackenzie Delta at 3 to 5 billion barrels of recoverable oil. Although there have been no official estimates of recoverable reserves in the far north, at the end of 1972 it appeared that discoveries there were still short of this amount.

Estimates of proven, nonconventional reserves were reported as a separate category by the CPA and were estimated to be 6.28 billion barrels at the end of 1972. These reserves include only the synthetic crude oil that is considered to be recoverable within an 'economic radius' of the Great Canadian Oil Sands plant near Fort McMurray and were based on the concept that the deposits within this radius may be expected to have equivalent or better characteristics than the deposits currently under development. No synthetic crude reserves have yet been estimated for the proposed Syncrude project. Ultimate recoverable reserves for the Athabasca-type oil sands by all known methods of recovery were in 1963, estimated by the Alberta Energy Resources Conservation Board, to be over 300 billion barrels.

Table 5. Canada, year-end reserves of crude oil, 1971-72

Province or Region	1972	% of Total 1971	% of Total 1972	Net Change 1972 over 1971
	('000 bbl)			('000 bbl)
Alberta	7,103,381	88.2	88.6	−247,201
Saskatchewan	594,205	7.6	7.5	− 36,429
British Columbia	219,728	3.0	2.7	− 28,821
Northwest Territories	42,933	0.5	0.5	− 989
Manitoba	48,820	0.6	0.6	− 6,597
Eastern Canada	11,074	0.1	0.1	+ 7,091
Total	8,020,141	100.0	100.0	−312,946

Source: Canadian Petroleum Association.

Table 6. Canada, reserves of liquid hydrocarbons at the end of 1972

	Natural Gas Liquids	Crude Oil Plus Natural Gas Liquids	% of Total
	('000 bbl)	('000 bbl)	
Alberta	1,654,966	8,758,347	90.1
Saskatchewan	8,648	602,853	6.2
British Columbia	39,465	259,193	2.7
Other areas	–	102,827	1.0
Total	1,703,079	9,723,220	100.0

Source: Canadian Petroleum Association.
– Nil.

Exploration and development

Alberta. Exploratory and development drilling footages were increased in 1972 partly because of the incentive provided by higher prices for both oil and gas. Both footages and number of wells increased as 2,719 wells were drilled with an aggregate footage of 10.05 million feet compared with 2,014 wells and 7.98 million feet in 1971. Many of the wells were drilled in the southern part of the province where shallow gas deposits are being actively explored for and developed. Despite increased exploration drilling, no new oil discoveries of any substance were made during 1972.

Probably the most noteworthy discovery occurred at the northwestern tip of the Willesden Green field when an exploratory test encountered commercial production in the Cretaceous Belly River Formation. Preliminary evaluation indicated that the new pool contains 30 million barrels of oil in place and a multi-well development program was under way at year-end. What may be a significant discovery was made 2 miles south of the Wood River oil field when an exploratory test encountered a highly productive zone in the Nisku D2 formation. Although a step-out well drilled southwest of the discovery was unsuccessful, further drilling is planned northwest of the high-potential discovery well in an attempt to determine the limits of the pool in that direction. An exploratory well drilled in the Crossfield East field confirmed the existence of an oil pool underlying the known gas reserves of the Elkton "A" pool. Original oil in place was estimated to be 45 million barrels and the operator has requested permission from the AERCB to produce this oil at 3,000 b/d.

The Rainbow-Zama Lake area of northwestern Alberta continued to sustain some industry interest which was rewarded with a few Keg River reef discoveries within the designated field boundaries. A well, drilled near the northwest extremity of the Rainbow field limits, penetrated 130 feet of productive Keg River reef. Another well drilled within the limits of the Zama oil field, just to the north of the Rainbow field, also encountered a thick zone in a separate Middle Devonian Keg River reef. The oil accumulations at both the Zama and Rainbow fields are associated with pinnacle-type reefs which are usually less than 100 acres in areal extent but highly productive nevertheless. As in previous years, several small discoveries were made in the central and southern regions of the province. In terms of reserves, however, these new fields contributed only marginally to the provincial total.

In recognition of the fact that crude oil reserves are diminishing, the Alberta government introduced two exploration incentive programs which are designed to encourage exploration in the province. The first provides a new system of credits for all new field wildcats which allow deductions from royalties, rentals and taxes to cover a portion of drilling costs. The second incentive provides for an extension in the remission of taxes and royalties on new oil discoveries in Alberta, to ensure credits for a full five years on any oil discovery made prior to the end of 1977.

To increase the recovery of oil from fields and thereby increase reserves, secondary recovery schemes have been implemented in Alberta oil fields wherever practical. Several more major enhanced recovery schemes were either initiated or received approval by the AERCB in 1972. Amongst the most important of these was Amoco Canada Petroleum Company Ltd.'s project to convert its existing Swan Hills South waterflood recovery project to a solvent flood, utilizing solvent, gas and water injection. This new recovery scheme is expected to provide an additional 105 million barrels of recoverable oil. Two other proposals were submitted to the AERCB for approval at year-end. One of these is Union Oil Company of Canada Limited's pilot waterflood recovery project to be installed in the Red Earth field. The other is Gulf Oil Canada Limited's proposed waterflood project in the Meekwap D2 oil field of north-central Alberta. These projects are expected to increase significantly the recoverable reserves of both fields.

Saskatchewan and Manitoba. Drilling footages and completions again declined in Saskatchewan and Manitoba. Total footage in Saskatchewan amounted to 1.81 million feet, the same as in the previous year. In Manitoba, footage drilled declined by 60 per cent to 16,890 feet. There were no discoveries made in either province this year. The possibility that the 1971 Jurassic discovery in the Cypress Hills area of southwest Saskatchewan might establish a new productive trend, failed to materialize as several step-out wells were drilled in this area during 1972 and all were unsuccessful. Exploratory drilling in Manitoba has virtually ceased as only two wildcat wells were drilled in 1972.

In oil field development, the Viewfield Mississip-

Table 7. Canada, wells completed and footage drilled

	1955		1960		1971		1972	
	(no.)	(ft)	(no.)	(ft)	(no.)	(ft)	(no.)	(ft)
Western Canada								
Westcoast offshore								
New field wildcats	–	–	–	–	–	–	–	–
Hudson Bay offshore								
New field wildcats	–	–	–	–	–	–	–	–
British Columbia								
New field wildcats	34	194,014	60	365,818	21	122,680	22	178,206
Other exploratory	2	13,020	11	55,749	77	396,127	102	522,757
Development	–	–	72	331,740	96	462,084	93	441,987
	36	207,034	143	753,307	194	980,891	217	1,142,950
Alberta								
New field wildcats	307	1,773,980	338	2,078,876	256	1,211,908	405	2,001,701
Other exploratory	105	436,941	223	1,171,079	751	3,075,750	795	3,120,564
Development	1,208	6,219,810	1,131	7,125,856	1,007	3,692,853	1,519	4,929,202
	1,620	8,430,731	1,692	10,375,811	2,014	7,980,511	2,719	10,051,467
Saskatchewan								
New field wildcats	312	1,182,727	113	468,507	112	375,883	132	364,916
Other exploratory	50	179,511	28	99,203	147	439,879	117	367,494
Development	550	1,873,040	461	1,795,968	376	999,276	385	1,083,027
	912	3,235,278	602	2,363,678	635	1,815,038	634	1,815,437
Manitoba								
New field wildcats	59	174,313	10	30,505	4	13,731	6	16,890
Other exploratory	10	23,743	3	6,370	1	2,150	–	–
Development	292	647,379	54	110,073	10	26,858	–	–
	361	845,435	67	146,948	15	42,739	6	16,890
Territories and Arctic islands								
New field wildcats	9	12,266	32	105,969	75	466,232	65	511,485
Other exploratory	–	–	–	–	1	3,055	5	57,230
Development	–	–	–	–	–	–	1	5,387
	9	12,266	32	105,969	76	469,287	71	574,102
Total, western Canada								
New field wildcats	718	3,337,300	553	3,049,675	468	2,190,434	630	3,073,198
Other exploratory	167	653,215	265	1,332,401	977	3,916,961	1,019	4,068,045
Development	2,050	8,740,229	1,718	9,363,637	1,489	5,181,071	1,998	6,459,603
	2,935	12,730,744	2,536	13,745,713	2,934	11,288,466	3,647	13,600,846
Eastern Canada								
Eastcoast offshore								
New field wildcats	–	–	–	–	19	204,366	18	191,210
					19	204,366	18	191,210
Ontario								
New field wildcats	64	112,246	39	68,393	55	111,128	79	139,172
Other exploratory	57	92,536	55	109,839	9	17,470	9	14,998

Table 7 (concl'd)

	1955		1960		1971		1972	
	(no.)	(ft)	(no.)	(ft)	(no.)	(ft)	(no.)	(ft)
Ontario (cont'd)								
Development	266	271,191	213	228,190	68	119,846	47	77,852
	387	475,973	307	406,422	132	248,444	135	232,022
Quebec								
New field wildcats	9	10,226	5	4,287	5	28,555	7	59,915
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	1	240	–	–	–	–
	9	10,226	6	4,527	5	28,555	7	59,915
New Brunswick								
New field wildcats	1	3,414	2	13,023	1	4,416	–	–
Other exploratory	–	–	–	–	–	–	–	–
Development	7	21,143	–	–	–	–	–	–
	8	24,557	2	13,023	1	4,416	–	–
Nova Scotia								
New field wildcats	–	–	1	9,840	–	–	–	–
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	–	–	1	9,840	–	–	–	–
Prince Edward Island								
New field wildcats	–	–	–	–	–	–	2	25,000
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	2	25,000
Total, eastern Canada								
New field wildcats	75	127,267	47	95,543	80	348,465	106	415,297
Other exploratory	57	92,536	55	109,839	9	17,470	9	14,998
Development	273	292,334	214	228,430	68	119,846	47	77,852
	405	512,137	316	433,812	157	485,781	162	508,147
Total, Canada								
New field wildcats	793	3,464,567	600	3,145,218	548	2,538,899	736	3,488,495
Other exploratory	224	745,751	320	1,442,240	986	3,934,431	1,028	4,083,043
Development	2,323	9,032,563	1,932	9,592,067	1,557	5,300,917	2,045	6,537,455
Total	3,340	13,242,881	2,852	14,179,525	3,091	11,774,247	3,809	14,108,993

Source: Canadian Petroleum Association.
– Nil.

pian pool in southeast Saskatchewan continued to be the bright spot in the development drilling picture. The discovery well was drilled in 1969 but it was not until 1971 before it began to be actively exploited. Thirteen successful development wells were drilled in 1972 adding substantially to the field's proven reserves. Much of the remaining development drilling in the province was confined to southwestern Saskatchewan where the Jurassic Dollard, Rapdan and Illebrun fields were still being expanded. To the north, a few development wells were drilled in the northeast corner of the Viking Dodsland field, expanding the field limits in that direction.

Concerned by the declining provincial reserves and the slowdown in industry exploration activity, the Saskatchewan government announced early in 1973 that it would form a Crown corporation for the purpose of exploring for oil and gas in the province. Although the final details were still under consideration, the new company was formed to take steps to

Table 8. Wells drilled by province, 1971-72

	Oil		Gas		Dry[1]		Total	
	1971	1972^p	1971	1972^p	1971	1972^p	1971	1972^p
Western Canada								
Alberta	361	514	691	1,010	962	1,195	2,014	2,719
Saskatchewan	266	316	108	86	261	232	635	634
British Columbia	46	37	36	61	112	119	194	217
Manitoba	2	–	–	–	13	6	15	6
Yukon and Northwest Territories	1	1	3	7	72	63	76	71
Westcoast offshore	–	–	–	–	–	–	–	–
Hudson Bay offshore	–	–	–	–	–	–	–	–
Subtotal	676	868	838	1,164	1,420	1,615	2,934	3,647
Eastern Canada								
Ontario	2	4	47	34	83	97	132	135
Quebec	–	–	–	–	5	7	5	7
Atlantic provinces	–	–	–	–	1	2	1	2
Eastcoast offshore	–	–	1	2	18	16	19	18
Subtotal	2	4	48	36	107	122	157	162
Total, Canada	678	872	886	1,200	1,527	1,737	3,091	3,809

Source: Canadian Petroleum Association.
[1] Includes suspended and abandoned wells.
^{p}Preliminary; – Nil.

reverse the declining exploration and development activity in the province. The new company is expected to concentrate its efforts on exploring deeper prospects, something which the Saskatchewan government believes industry has largely neglected.

Table 9. Oil wells in western Canada at the end of 1971-72

	Producing Wells		Wells Capable of Production	
	1971	1972	1971	1972
Alberta	9,467	9,689	14,065	14,168
Saskatchewan	6,177	6,390	7,314	7,421
Manitoba	695	638	900	900
British Columbia	556	566	677	685
Northwest Territories and Arctic islands	37	44	63	64
Total	16,932	17,327	23,019	23,238

Source: Provincial and federal government reports.

British Columbia. Although development drilling decreased in 1972, exploratory drilling increased by 35 per cent to 701,963 feet from 518,807 feet in 1971. Much of the increased exploratory footage can be attributed to an upswing in the search for new gas reserves. Only one exploratory well drilled during the year yielded significant quantities of oil on test; it was in the Fort Nelson area. However, subsequent testing and drilling proved this discovery to be noncommercial. Most of the development drilling was again confined to the Boundary Lake Triassic pool where several more infill wells were drilled during the year. Some development drilling was carried out in the Weasel and Inga fields.

Yukon Territory, Northwest Territories and Arctic islands. Total exploratory drilling in northern regions was increased by 21 per cent to 574,102 feet, reflecting the increased interest in this area. The high degree of success attained in 1971 by explorationists in Canada's northern regions, particularly the Arctic islands and the Mackenzie Delta, continued into 1972. Although the majority of discoveries were natural gas, Imperial Oil Limited made a very significant oil discovery in the Mackenzie Delta at their Ivik-J-26 well drilled on Richards Island. The well, Ivik-J-26, encountered several sandstone beds below 8,100 feet which, on test, yielded substantial flows of crude oil and natural gas. This is the third oil discovery made in the Mackenzie Delta area since concerted drilling activity began in 1969. The other two discoveries were IOE Atkinson H-25 discovered in 1970 and IOE Mayogiak J-17 discovered in 1971. Both are located on the Tuktoyaktuk Peninsula. The Atkinson well was released from the confidential list and some of the data on its productive capabilities were made available. The operating company reported that the producing formation flowed oil to surface at an average rate of 2,000 b/d from a pay zone 123 feet thick. Neither of the earlier oil discoveries were developed although a few step-out wells drilled at both locations were unsuccessful.

In the same general area, four gas-condensate discoveries have been made, some of which are likely to be of major significance. In addition to the IOE Taglu G-33 discovery made in 1971 and the IOE Mallik L-38 and IOE Taglu West discoveries made in early 1972, three more gas condensate discoveries were recorded in the Delta region during 1972. In the Parsons Lake area, a joint venture involving Gulf Oil Canada Limited and Mobil Oil Canada, Ltd. extended the potential area 43 miles southeast of Richards Island when their initial well, Gulf-Mobil Parsons Lake K-09, encountered significant quantities of gas and condensate from the 9,300-foot level. Early in 1973 three more significant gas discoveries were reported from two widely separated locations on Richards Island. The Gulf Mobil Ya Ya P-53 well, located 10 miles south of the original Taglu gas discovery, yielded gas from three separate zones on test. Ten miles to the south, Gulf Oil Canada, in partnership with Imperial Oil and Shell Canada, announced that the Gulf Imperial Shell Titalik K-26 well tested significant flows of gas from a zone below the 5,800-foot level. Ten miles west of the Taglu discovery, Shell reported that their Niglintgak H-30 well had penetrated several porous sandstone horizons in the interval between 2,500 and 3,566 feet which appeared to be hydrocarbon bearing on preliminary analysis. The well is currently being deepened prior to further testing. Although further drilling and testing will be required to determine the size of all of these discoveries, the chances are good that a gas reserve large enough to economically justify constructing a pipeline to southern markets is close to being established. At the beginning of 1973, there were 13 drilling rigs operating in the Mackenzie Delta and several operators new to the area had joined the search.

In the Arctic islands, Panarctic Oils Ltd., the industry-government company, accelerated its exploration program and was rewarded with several more discoveries, most of them gas. On Melville Island, Panarctic successfully completed a gas well 12 miles southeast of its 1970 gas discovery on Drake Point. The new well, located near the seacoast and drilled on the same structure as the discovery well, confirmed the extension of the Drake Point reservoir which probably continues out into the Arctic Ocean. Reserves at Drake Point, although not fully determined, are likely to be about 5 trillion cubic feet. Very late in the year Panarctic announced a new gas find at its Panarctic et al. P.O.R. Hecla-F-62 well, located on the western coast of the Sabine Peninsula of Melville Island. The structure on which the discovery is located is believed to be large, extending for about 10 miles offshore and is from 6 to 8 miles in width. The well is located 30 miles west of the major gas find at Drake Point and is the fourth made by Panarctic in its Arctic drilling program. The fifth major gas discovery was recorded early in 1973 when Dome Petroleum Limited reported that its well, Dome Arctic Venture's Wallis K-62 on King Christian Island, encountered a gas-bearing sandstone that yielded gas and condensate on test. It is not known whether there is an oil column associated with the gas. This is the second major discovery on King Christian Island and preliminary evaluation suggests that this may be the largest discovery yet made in the Arctic islands. Step-out drilling for both the Hecla and Wallis wells is scheduled for 1973 to more fully determine the size of the discoveries. Industry officials now estimate that these two discoveries, in combination with the Drake Point extension and earlier discoveries at King Christian Island and Kristoffer Bay on Ellef Ringnes Island, had outlined more than half of the 30 trillion cubic feet of gas reserves which is considered to be the minimal amount required to support a major natural gas pipeline from the Arctic islands.

Panarctic made its first oil discovery at Romulus on Ellesmere Island in 1972 when its exploratory well encountered three separate oil zones but this find was subsequently proven to be noncommercial. Nevertheless, it serves to substantiate that oil is present. Shortly afterwards, Panarctic reported a light oil discovery on the southern tip of Thor Island. The well penetrated a thin productive zone but it is now postulated that this zone represents only the edge of a much thicker reservoir, the bulk of which lies offshore. To test this hypothesis, Panarctic has scheduled a follow-up well for this winter to be drilled at 45° from a location on the east shore that would bottom at a considerable distance from the shoreline. At year-end there were 11 drilling rigs operating in the Arctic islands.

Eastern Canada. In Ontario, total footage drilled amounted to 232,022 feet, a 6 per cent decrease from 1971. Exploratory drilling accounted for 66 per cent of the total and declined 25,572 feet from the previous year. A few small oil discoveries were made this year, including a Cambrian discovery in Dunwich Township on the west flank of the Willey field and a small Silurian reef discovery in Lambton County. Development drilling decreased 35 per cent with 47 completions in 1972, compared with 68 in 1971. Out of 38 successful completions only four oil development wells were completed; the remaining 34 were gas wells. In Quebec, there were seven exploratory wells drilled this year; all were unsuccessful.

In the eastern offshore region, which includes the Atlantic area from the Canada-United States international boundary south and west of Nova Scotia to Baffin Bay in the Arctic, 54 wells had been drilled to the end of 1972. Two of these exploratory tests have been confirmed as commercial successes and the remainder were dry and abandoned, although many of these had indications of oil and gas. In addition to the oil and gas discovery made on the western tip of Sable Island in 1971, a new gas-condensate discovery was made by the Mobil-Tetco Thebaud P-84 well 6 miles southwest of the E-48 discovery well. The Thebaud well is located on a separate structure and encountered a series of zones that flowed gas at rates of from 5 to 21 million cubic feet a day and three of these zones also produced condensate. An offset well, Mobil Tetco H-58 drilled shortly thereafter, recovered both oil and gas on a production test of zones below 5,000 feet.

In April, another significant exploratory test was drilled 30 miles east of Sable Island. The Shell-Primrose N-50 well tested substantial flows of sweet gas from three productive zones and minor quantities of condensate were associated with the gas. A fourth zone tested oil at 300 barrels per day. Two step-out wells drilled later in the year, failed to find other deeper productive formations but did establish the continuity of the original gas-bearing zone. The structural control in this area is a salt dome, further complicated by faulting; so three or four more offset wells may be required to determine the full potential of the structure.

Shortly after the initial discovery on Sable Island, a step-out well was drilled 4,000 feet to the east which tested significant hydrocarbon flows from zones at depths considerably below those of the original discovery. Both of these discoveries are now being evaluated by directionally controlled drilling from a fixed platform built on the extreme northwest corner of Sable Island.

On the Grand Banks, nine wells were drilled but none were successful, although a few were reported to have indications of hydrocarbons. At year-end, three wells were being drilled on the Grand Banks: one 215 miles east of St. John's, Newfoundland, and the other two about the same distance south of Newfoundland. By the end of 1972, four semisubmersible rigs were operating on the eastern seaboard; by next summer the number could reach seven.

Table 10. Mileage in Canada of pipelines for crude oil, natural gas liquids and products

Year-end	Miles	Year-end	Miles[1]
1957	6,873	1965	12,315
1958	7,143	1966	12,995
1959	7,808	1967	14,155
1960	8,436	1968	14,832
1961	9,554	1969	17,075
1962	10,037	1970	17,062
1963	10,607	1971	17,837
1964	11,744	1972[e]	18,181

Source: Statistics Canada.
[1]Includes producer's gathering lines for 1969 to 1972.
[e]Estimate.

Table 11. Deliveries of crude oil and propane by company and destination, 1971-72

Company and Destination	1971	1972
	(millions of barrels)	
Interprovincial Pipe Line		
Western Canada	42.4	42.4
United States	171.7	214.2
Ontario	142.6	151.6
Total	356.7	408.2
Trans Mountain Pipe Line		
British Columbia	38.5	39.8
State of Washington	79.3	101.2
Westridge terminal	3.6	3.5
Total	121.4	144.5

Source: Company annual reports.

Transportation

Oil and product pipeline construction declined in 1972 as only 344 miles of new pipeline were put into operation and most of this consisted of intermediate and small-diameter line. The bulk of the large-diameter construction was restricted to natural gas transmission; nevertheless, a milestone was reached in pipeline construction in 1972 when Interprovincial Pipe Line Company installed 124 miles of 48-inch parallel line to its trunk system between Edmonton, Alberta and Superior, Wisconsin. This is the largest-diameter pipeline ever built in the Western Hemisphere and marks the start of Interprovincial's fourth line from Edmonton to Superior. At the same time, additional pumping capacity was installed at 26 stations and additional storage capacity at four stations. Eighty miles of the new large-diameter line was constructed in Canada and, at the end of 1972, the Interprovincial system capacity east of Cromer, Manitoba had been increased by 127,000 b/d to 1,435,000 b/d. Interprovincial's 20-inch line has been converted exclusively to transporting products and gas liquids and in this connection will transport products to major Prairie marketing centres from Imperial Oil's new Edmonton refinery when it is completed in 1974.

Late in 1972, Wascana Pipe Line Ltd. completed its 107-mile 12 3/4-inch crude oil and condensate line from the Interprovincial pipeline in Regina to the international boundary near Regway, Saskatchewan where it connects with a United States pipeline. The line commenced operating in January 1973 and is capable of supplying up to 30,000 b/d of crude oil and condensate to mid-United States markets. There were no other significant oil or product pipeline projects completed in Canada this year.

At year-end there were two major product pipeline proposals still awaiting approval by Canadian and United States government regulatory authorities. One of these is Dome Petroleum Limited's proposal to construct a 1,600-mile pipeline from Edmonton to Sarnia via the United States to carry light liquid hydrocarbons. Under this scheme, Dome would supply not only its own fractionation plant which it would build at Sarnia but export an additional 113 million barrels of propane and 139 million barrels of ethane over ten years to two United States firms. A third cross-Canada pipeline system was also under consideration by a group of producing and pipeline companies called the White Products Pipe Line Study Group, which had completed a feasibility study of a pipeline system to carry propane, butane and condensate from Alberta via Regina to a point near Minneapolis and move refined products from Edmonton to Prairie marketing centres such as Saskatoon, Regina, Brandon and Winnipeg. Another feasibility study, to explore the possibility of constructing a 600-mile crude oil pipeline from a deepwater port on the St. Lawrence River, via Montreal to Buffalo has been completed by Ashland Oil Canada Limited and New England Petroleum Corp. This plan envisages the construction of a deepwater terminal capable of handling very large crude carriers and would be located 130 miles east of Quebec City. Under the scheme, a 42-inch pipeline with a throughput of 500,000 b/d would be constructed on the south shore of the St. Lawrence River to Montreal to serve the Montreal refineries. From Montreal, a smaller line would be built through New York State for the dual purpose of serving a proposed fuel treatment plant at Oswego and Ashland's refinery at Buffalo. It is interesting to note that Montreal's six refineries are currently being served by a pipeline from Portland, Maine, which is a fairly shallow harbour and unable to handle the new supertankers.

Mackenzie Valley Pipe Line Research Limited completed its three-year research program on the economic and ecologic feasibility of construcing crude oil pipelines in permafrost areas. The results of this study were set out in a report which concluded that it was technically feasible to construct and operate the line without major or irreparable damage to the Arctic environment. The study dealt specifically with the longstanding project for a 1,738-mile, 48-inch pipeline from the Alaska North Slope to Edmonton, with throughput capacity of 1.8 million b/d and to cost $3.4 billion. The company is continuing studies on an all-Canadian pipeline out of the Mackenzie Delta to Edmonton as an alternative. This project would be contingent on the establishment of an adequate crude oil reserve base in the Canadian Arctic mainland and would include a pipeline 1,400 miles long to cost about $3.4 billion.

The only significant changes in pipeline tariffs during the year were made by Interprovincial, which reduced its short-haul rates by amounts ranging from 0.6 cent to 2 cents per barrel and long-haul rates by 1 cent per barrel. As a result, rates from Edmonton to Regina were reduced 2 cents to 18.7 cents per barrel and rates from Edmonton to Sarnia, Toronto and Buffalo were reduced by 1 cent to 47.0, 50.0 and 52.0 cents per barrel, respectively. There were no changes in the tariff schedule of the other major crude oil carrier, Trans Mountain Pipe Line Company Ltd., as the basic pipeline rates from Edmonton to Burnaby, British Columbia and Anacortes, Washington, remained unchanged at 40 cents a barrel.

Table 12. Crude oil refining capacity by regions

	1971		1972	
	(bbl/day)	(%)	(bbl/day)	(%)
Atlantic provinces	294,300	17.6	312,500	18.1
Quebec	577,500	34.5	587,500	34.0
Ontario	389,200	23.2	410,800	23.7
Prairies and Northwest Territories	288,700	17.2	290,200	16.8
British Columbia	125,800	7.5	129,300	7.4
Total	1,675,500	100.0	1,730,300	100.0

Source: Department of Energy, Mines and Resources, Petroleum Refineries in Canada (*Operators List* 5), January 1973.

Petroleum refining

Although refinery capacity showed only a slight increase in 1972, major projects nearing completion and future prospects for new refinery construction have assured significant growth in plant capacity during the next few years. Crude oil refining capacity of all plants in Canada totalled 1,730,300 b/d, an increase of only 54,800 b/d over the 1971 capacity. The number of operating refineries remained at 40, as in the previous year.

In the Atlantic provinces, Imperial Oil Limited increased the capacity of its Dartmouth, Nova Scotia refinery by 18,200 b/d and at the same time com-

Table 13. Canada, crude oil received at refineries, 1971 and 1972p

Location of Refineries		Country of Origin							Total Received
		Canada	Middle East	Trinidad	Venezuela	Africa	Colombia	Other	
					(barrels)				
Atlantic provinces	1971	591	28,881,537	–	36,405,561	–	272,731	7,754,747	73,315,167
	1972	–	47,552,806	–	33,144,106	49,932	–	16,438,472	97,185,316
Quebec	1971	–	28,025,166	–	110,983,635	24,126,919	7,365,877	–	170,501,597
	1972	–	51,843,338	1,308,823	108,862,414	21,306,862	4,450,655	3,372,433	191,144,525
Ontario	1971	135,478,112	–	–	408,649	–	–	–	135,886,761
	1972	137,477,565	–	–	424,391	–	–	–	137,901,956
Prairies	1971	80,704,216	–	–	–	–	–	–	80,704,216
	1972	87,329,474	–	–	–	–	–	–	87,329,474
British Columbia	1971	46,141,994	–	–	–	–	–	–	46,141,994
	1972	47,567,342	–	–	–	–	–	–	47,567,342
Northwest Territories and Yukon	1971	914,255	–	–	–	–	–	–	914,255
	1972	912,926	–	–	–	–	–	–	912,926
Total	1971	263,239,168	56,906,703	–	147,797,845	24,126,919	7,638,608	7,754,747	507,463,990
	1972	273,287,307	99,396,144	1,308,823	142,430,911	21,356,794	4,450,655	19,810,905	562,041,539

Source: Statistics Canada.
pPreliminary.

pleted its pollution abatement program at the plant. At Come By Chance in Newfoundland, construction of Newfoundland Refining Company Limited's 100,000 b/d refinery is proceeding on schedule and should be completed by mid-1973. The refinery is equipped with modern pollution control equipment and will process Kuwait and Iranian crude oil. A flexible processing system will produce jet fuel, gasoline and low-sulphur residual and light fuel oil primarily for export to European and northeastern United States markets. The availability of excellent, potential deep-water harbour sites in the Maritime Provinces combined with the growing market for refined petroleum products, particularly low-sulphur fuel oils in the northeastern United States, has prompted proposals for the construction of major new refineries in the Atlantic provinces. Among the most important of these are two large refineries to be constructed by Shaheen Natural Resources Company Inc., New York, the company which is building the Come By Chance refinery. One of these is a 200,000 b/d facility to be located across the Canso Strait from Gulf Oil Canada Limited's two-year-old Point Tupper refinery. The new refinery would cost approximately $223 million and is anticipated to go on stream early in 1975. The other proposed refinery would be built at Come By Chance close to the plant now under construction and would have a capacity of 300,000 b/d, the largest ever built in Canada. The proposed refinery would use foreign crude oil, and produce mainly low-sulphur fuel oil for markets in the United States and the European Economic Community. Initial production is envisaged for the first half of 1976. In addition, Northeast Petroleum Corp. of Boston tentatively has plans to construct a transshipment terminal and large refinery at Saint John, New Brunswick.

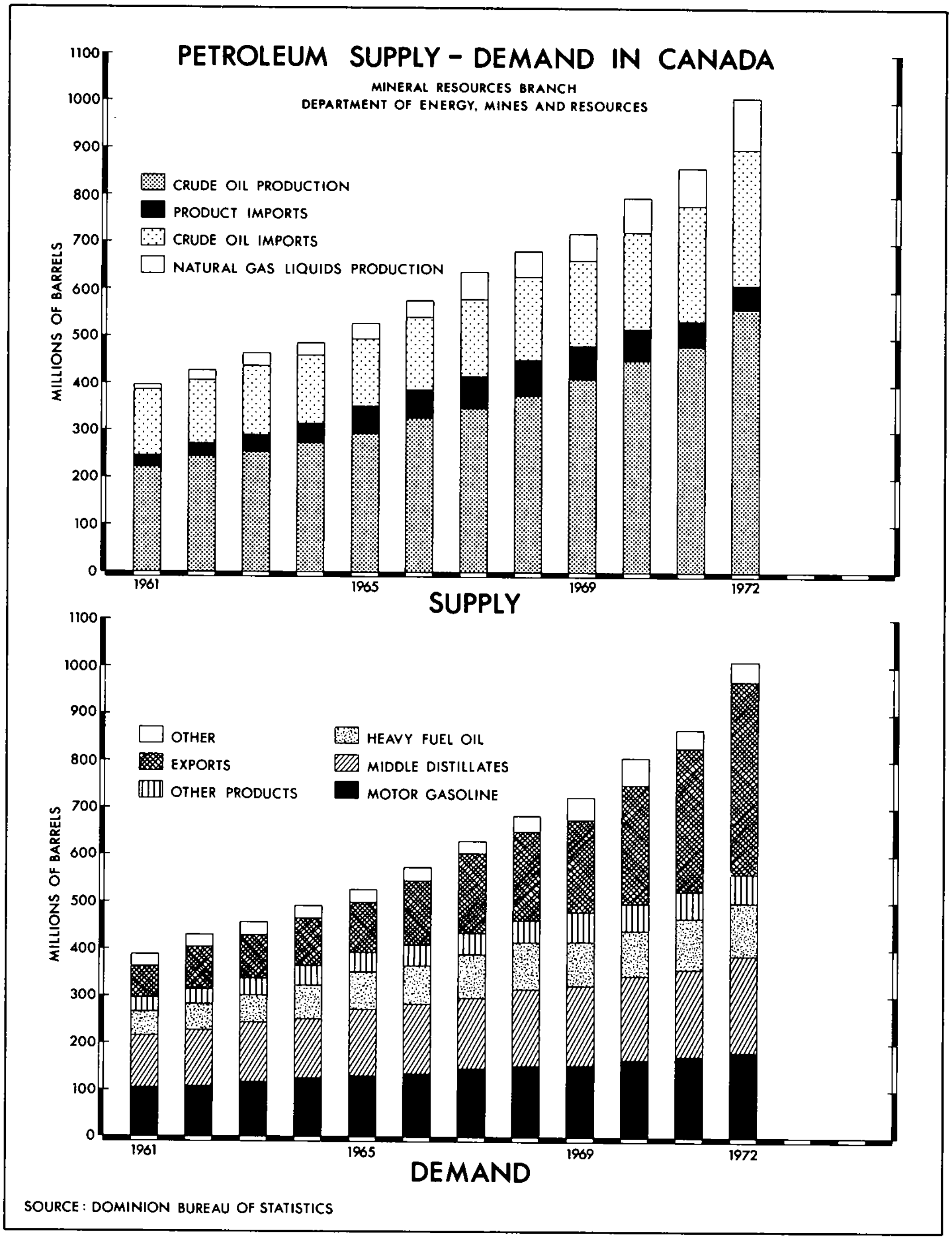
In Quebec, refinery development consisted of a 10,000 b/d increase in crude oil refinery capacity by Shell Canada Limited and the addition of a 16,000 b/d hydrocracker by Petrofina Canada Ltd., both at Montreal. In Ontario, refinery growth was confined to a 12,000 b/d crude oil capacity increase by Shell at its Corunna refinery and minor expansions by Regent Refining (Canada) Limited at Port Credit and Imperial Oil Limited at Sarnia. The status of Texaco Canada Limited's proposed 50,000 b/d refinery on Lake Erie near Nanticoke was still uncertain at year-end. In 1973, BP Refinery Canada Limited will begin a 40,000 b/d expansion of its Oakville refinery. Completion is scheduled for 1974 when BP will be able to satisfy all the requirements of its southern Ontario retail outlets from its own facilities. Sun Oil Company Limited will increase the capacity of its Sarnia refinery from 33,000 to 80,000 b/d. Along with the increased capacity, Sun's planned changes include modifications to existing facilities to reduce sulphur levels in distillate fuel oils and the addition of several environmental control features. Construction will begin in 1973 with completion scheduled for 1974.

On the Prairies, construction began on Imperial Oil's 140,000 b/d Strathcona refinery on the site of their existing plant at Edmonton. Completion is scheduled for late 1974. The Strathcona refinery will be the hub of a new product supply system which Imperial is building in the Prairie Provinces. A pipeline system will link the new plant with other terminals at major Prairie centres and when the Strathcona refinery is completed, Imperial's existing smaller refineries at Regina, Calgary and Winnipeg will be converted to petroleum product distribution terminals. These terminals are part of the planned $200 million petroleum product supply system for the Prairies, which will be

Table 14. Regional consumption of petroleum products by province, 1972^p

	Motor Gasoline	Kerosene, Stove Oil, Tractor Fuel	Diesel Fuel Oil	Light Fuel Oils No. 2 and 3	Heavy Fuel Oils No. 4, 5 and 6
	(thousands of barrels)				
Newfoundland	3,546	1,822	3,612	3,549	3,679
Maritimes	11,859	3,133	4,138	13,750	25,886
Quebec	44,637	6,978	9,745	39,549	44,086
Ontario	67,794	3,138	12,205	41,658	26,706
Manitoba	8,669	1,551	3,828	1,854	868
Saskatchewan	10,581	1,258	4,354	1,556	622
Alberta	18,030	534	7,087	897	654
British Columbia	19,053	1,935	9,502	7,149	8,618
Northwest Territories and Yukon	505	334	1,437	576	139
Total	184,674	20,683	55,908	110,538	111,258

Source: Statistics Canada.
^{p}Preliminary.


PETROLEUM SUPPLY - DEMAND IN CANADA
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
CRUDE OIL PRODUCTION
PRODUCT IMPORTS
CRUDE OIL IMPORTS
NATURAL GAS LIQUIDS PRODUCTION
MILLIONS OF BARRELS
0
100
200
300
400
500
600
700
800
900
1000
1100
1961
1965
1969
1972
SUPPLY
OTHER
EXPORTS
OTHER PRODUCTS
HEAVY FUEL OIL
MIDDLE DISTILLATES
MOTOR GASOLINE
MILLIONS OF BARRELS
1961
1965
1969
1972
DEMAND
SOURCE: DOMINION BUREAU OF STATISTICS

linked by pipeline with the Strathcona refinery. Elsewhere on the Prairies, Husky Oil Ltd. has increased the capacity of its Lloydminster plant by 1,000 b/d and has converted it exclusively to asphalt production. Under an agreement with Gulf, Husky will provide Gulf with substantial quantities of asphalt from this refinery in return for diesel fuel and gasoline from Gulf's Edmonton refinery.

On a company basis, Imperial Oil Enterprises Ltd. remained the largest refiner in Canada. The company's nine refineries comprise 27 per cent of Canadian refinery capacity. Gulf Oil Canada Limited's eight plants constitute 19 per cent of Canadian refinery capacity and Shell Canada Limited, third largest refiner, operates six refineries which account for 16 per cent of the total.

Marketing and trade

Crude oil deliveries to Canadian refineries during 1972 averaged 1.54 million barrels a day, approximately 11 per cent more than in 1971. Refineries in western Canada and Ontario increased their crude oil consumption by 3.7 per cent taking an average of 749,000 barrels of Canadian oil daily. On the other hand, use of imported crude oil by Canadian refineries in Quebec and the Maritime Provinces was substantially greater in 1972, increasing by 123,000 b/d, or 18.2 per cent. The start of full-scale production at the two large, new eastern Canadian refineries, the Golden Eagle Canada Limited refinery at St-Romuald, Quebec, and the Gulf Oil Canada plant at Point Tupper, Nova Scotia, was the main reason for this large increase in the use of offshore crude oil. Production from these two refineries is replacing imported refined petroleum products in eastern Canadian markets and, at the same time, proving to be a major supplier of petroleum products to United States east coast markets. Product imports, consisting primarily of light and heavy fuel oil, declined in 1972 for the second consecutive year and now stand at 147,000 b/d. This is 11,000 b/d less than in 1971 and considerably less than the maximum level of product imports of 200,000 b/d recorded in 1969.

Although Venezuela was still the largest exporter of crude oil to Canada, the volume of its exports declined from 406,000 b/d in 1971 to 391,000 b/d in 1972. Middle East countries significantly expanded their share of the Canadian import market, increasing exports from 156,000 b/d in 1971 to 273,000 b/d in 1972. The Middle East sources were Iran, Saudi Arabia, Iraq, Kuwait, Quatar, Bahrain and the Trucial States. Nigeria continued to provide substantial amounts of crude oil to Canadian refineries, although import volumes from this country declined by 8,000 b/d to 58,000 b/d. Imports from Colombia were almost halved, declining to 12,000 b/d.

Export demand for Canadian crude oil and equivalent increased by 26 per cent to 935,000 b/d and all of this went to the United States. Refiners in the west coast Puget Sound area imported 276,000 b/d, up 59,000 b/d for a gain of more than 27 per cent. Exports to markets east of the Rockies (Districts 1-4), primarily via Interprovincial's main line amounted to 659,000 b/d, 26 per cent greater than in 1971. The 1972 quota for Canadian exports of crude oil to Districts 1-4 as set by the United States was 582,000 b/d. Excluded from this quota are batch shipments of condensate, pentanes plus and special allowances to some United States purchasers which in total, raise the formal allocations by approximately another 100,000 b/d.

Government actions at both federal and provincial levels were major events in Canada's oil industry in 1972 and will likely significantly affect future pricing and marketing trends. In western Canada, the Alberta government initiated a new energy policy by introducing a plan whereby oil companies will have the option of paying either a tax on proven oil reserves or an increased royalty rate amounting to 5 per cent over the existing rate of 16 per cent. The new schedule became effective January 1, 1973 and is designed to provide an additional $70 million in provincial tax revenues from the producing sector of the oil and gas industry. Shortly thereafter, both the Saskatchewan and British Columbia governments also announced their intention to sharply increase provincial royalties on oil production. To offset the increased operating costs, the producing industry responded with increases in the posted price of crude oil, of 10 cents a barrel late in 1972 and 20 cents a barrel early in 1973.

Increasing concern that the burgeoning demand for Canadian crude oil by the United States might lead to shortfalls in supply to traditional Canadian markets, prompted the Canadian government to review its previous policy of allowing unrestricted growth of crude oil exports to the United States. As a result of the review, early in 1973, the federal government amended regulations made under Part VI of the National Energy Board Act. The amendments have the effect of bringing under licence the export of crude oil and equivalent hydrocarbons, but not refined oil products, effective March 1, 1973. Shortly thereafter, the federal government authorized the National Energy Board to order a reduction in exports of crude and equivalent to the United States for March, by 3.7 per cent. Although this action was taken to deal with what was considered to be a transient problem, federal authorities will be closely scrutinizing the determination of exportable surpluses of crude oil in the future.

In 1972, Canada for the first time became a net exporter of petroleum products, as exports increased by 78 per cent to 179,000 b/d. Exports of products now exceed imports by 32,000 b/d and this can be mainly attributed to the increasing demand for imported heavy fuel oil in the northeastern region of the United States. Outside of one small refinery in Rhode Island, there are no refineries on the northeast United States seaboard and none are planned for construction

Table 15. Canada, exports and imports of refined petroleum products, 1971-72

	Exports		Imports	
	1971	1972^p	1971	1972^p
	(millions of barrels)			
Propane and butane	23.49	31.30	0.06	0.08
Aviation gasoline	–	–	0.08	0.15
Motor gasoline	0.61	0.73	4.72	3.06
Aviation turbo fuel	0.28	1.11	1.67	2.21
Kerosene, stove oil and tractor fuel	0.08	0.12	1.59	1.53
Diesel fuel oil	0.30	0.10	3.34	2.69
Light fuel oils #2 and 3	1.25	2.03	9.84	10.65
Heavy fuel oil #4, 5 and 6	9.64	26.20	29.70	26.60
Asphalt	0.03	0.04	0.38	0.38
Petroleum coke	–	–	3.51	2.94
Lubricating oils	0.01	0.01	1.24	1.46
Other products	1.02	3.70	1.34	1.90
Total, all products	36.71	65.34	57.47	53.65

Source: Statistics Canada.
^{p}Preliminary; – Nil.

in the immediate future; therefore the New England states area must import virtually all of its petroleum products. The two large new refineries in St-Romuald, Quebec and Point Tupper, Nova Scotia are already serving this potentially large market and this service will be further extended when the 100,000 b/d refinery at Come By Chance, Newfoundland comes on stream in 1973. Export growth of propane and butane extracted from natural gas, continued to be expanded and, in 1972, increased by 33 per cent to 86,000 b/d. Most of this went to the United States, but exports via pipeline and tanker to Japan amounted to 9,500 b/d – about 3,800 b/d more than in 1971.

Although imports of crude oil and products accounted for 55 per cent of Canadian demand, record exports made Canada, for the second successive year, a net exporter of crude oil and petroleum products as exports exceeded imports by 64 million barrels or 175,000 b/d. The existing large refineries of eastern Canada and those that are being built are now, and will continue to be, dependent on foreign sources of crude oil. Production from these refineries will increase, not only as normal domestic requirements increase but, more significantly, will appreciably rise to meet the expected demand from the United States. As a result, it will appear statistically that imports of crude oil constitute a rising proportion of domestic demand, whereas in actual fact much of this demand is originating in the export market. This was true in 1972 when imports accounted for 55 per cent of domestic demand compared with 53 per cent in 1971. However, the significant feature is that net new production of crude oil and natural gas liquids exceeded Canadian demand for the second consecutive year. Canada, which became self-sufficient in petroleum in 1971, remained so in 1972.

Table 16. Canada, supply and demand of oils, 1971-72

	1971	1972^p
	(thousands of barrels)	
Supply		
Production		
Crude oil and condensate	492,739	562,453
Other natural gas liquids	85,678	108,523
Net production	578,417	670,976
Imports		
Crude oil	244,972	288,754
Products	57,370	53,645
Total imports	302,342	342,399
Change in stocks		
Crude and natural gas liquids	–2,188	–5,986
Refined petroleum products	–5,492	+3,765
Total change	–7,680	–2,221
Oils not accounted for	2,148	6,556
Total supply	875,227	1,017,710
Demand		
Exports		
Crude oil	270,770	341,253
Products	36,707	65,346
Total	307,477	406,599
Domestic sales		
Motor gasoline	173,386	184,541
Middle distillates	191,240	204,058
Heavy fuel oil	105,162	110,901
Other products	59,674	66,197
Total	529,462	565,697
Uses and losses		
Refining	36,218	41,413
Field,plant and pipeline	2,070	4,001
Total	38,288	45,414
Total demand	875,227	1,017,710

Sources: Statistics Canada and provincial government reports.
^{p}Preliminary.

Outlook

The outlook for Canada's oil industry hinges on a mixture of circumstances – some promising, others not. Marketing opportunities have never been more favourable but the reserve base to supply these markets shrank in 1972 and unless this trend is reversed, the Canadian producing industry will be able to sustain an increasing export growth rate only in the short term. Indeed, this too will depend upon the amount of oil that the authorities consider to be surplus to Canadian requirements at any particular time, taking into account both current production and transportation capabilities. It is also likely, in view of the huge oil requirements of the United States, that conventionally produced oil for export from present reserves will only go to traditional export markets, with incremental growth at the expense of other sources. Nevertheless, significant increases in crude oil exports are likely to be approved only if major new reserves are discovered or if nonconventional crude sources are developed. Expanding exploratory activity in the Arctic and offshore from the Maritime Provinces makes it apparent that companies operating in Canada consider these regions to be the most immediate answer to the problem of finding new major reserves. To date, they have yielded several major natural gas discoveries but no significant oil discoveries.

The growth in demand for petroleum products, together with increased prices and the limited potential for additional North American crude oil production, tended to re-emphasize the significance of the Athabasca tar sands as a major source of future energy supply. These factors, combined with improving economics has underlined the need for large-scale orderly development of this huge resource to contribute to meeting the equally huge projected energy demands of the 1980's. Such development will be a large undertaking, particularly in capital and human requirements, and will not be without technical problems.

The recent fiscal actions of governments, both at home and abroad, will lead to higher prices for crude oil and petroleum products. OPEC's success in persuading the international oil companies to transfer part ownership of their operations to member states, and in receiving higher returns for their production, is certain to have a long-term impact on world petroleum price structures. Since the price of Canadian crude oil is closely tied to international prices, the effect on the Canadian industry will be to further increase pressures for the upward pricing of domestic crude oil. As a result, in the coming year and beyond, Canadian consumers are faced with the prospect of paying more for petroleum products.

Phosphate

W.E. KOEPKE

Phosphate rock is not produced commercially in Canada but large quantities are imported, mostly from the United States, for use in the manufacture of agricultural and industrial phosphate products sold in domestic and export markets. The United States and Britain provide the largest export markets for the finished products, principally phosphorus and phosphate fertilizers.

About four fifths of the world's phosphate rock consumption is for agriculture, largely to fertilize soils deficient in phosphorus. World demand for phosphate rock expanded at unprecedented rates from 1963 to 1967 to meet the needs of a rapidly developing phosphate fertilizer industry, but eased considerably between 1968 and 1971. In Canada, demand for phosphate fertilizers soared from 1965 to 1968 but then dropped off sharply in 1969 and 1970 as farm incomes tended to level off. The past two years witnessed some strengthening in demand, especially during the latter part of 1972 and early 1973. Preliminary indications are that domestic consumption in the fertilizer year 1972/73 will be on par with the previous all-time high recorded in 1967/68.

Sluggish domestic demand in 1969-71 was, however, to a large extent offset by buoyant export demand mainly in the United States. In fact, exports of phosphate fertilizers, expressed in terms of P_2O_5 equivalent, in the fertilizer years 1970/71 and 1971/72 surpassed the 1969-70 level of domestic consumption.

Phosphate rock

Phosphate is a term applied to a rock, mineral, or salt containing one or more phosphorus compounds. Phosphate rock, or phosphorite, contains one or more suitable phosphate minerals, usually calcium phosphate, in sufficient quantity for use, either directly or after beneficiation, in the manufacture of phosphate products. Sedimentary phosphate rock is the most widely used phosphate raw material; apatite, which occurs in many igneous and metamorphic rocks and can be represented by the formula $Ca_5(PO_4)_3(F, Cl, OH)$, is second in importance. Other sources of phosphate include guano and a basic slag byproduct of some steel mills. Phosphate rock can be decomposed by three methods: acid treatment, thermal reduction, or thermal treatment without reduction. Canadian phosphate producers use the first two methods.

Phosphate rock is graded either on the basis of its P_2O_5 equivalent (phosphorus pentoxide) or $Ca_3P_2O_5$ content (tricalcium phosphate or bone phosphate of lime – BPL). For comparative purposes 0.458 P_2O_5 equals 1.0 BPL and one unit of P_2O_5 contains 43.6 per cent phosphorus.

Occurrences in Canada. There are numerous occurrences of low-grade phosphate rock in Canada. They are of limited extent and fall into three main categories, as follows: apatite deposits within Precambrian metamorphic rocks in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes in Ontario and Quebec; and Late Paleozoic-Early Mesozoic sedimentary phosphate rock deposits in the southern Rocky Mountains.

The Precambrian metamorphic apatite deposits of Ontario and Quebec occur in pyroxenites as small, irregular, scattered pockets and veins with phlogopite mica and pink calcite. Most of the outcrops are in the Rideau Lakes region of eastern Ontario and the Lièvre River area of southwestern Quebec, where many deposits were worked extensively between 1869 and 1900, before low-cost Florida rock entered world markets. Among the more important alkaline-complex apatite occurrences are: the Nemegos deposits, some 150 miles northwest of Sudbury; the Oka deposit, 20 miles west of Montreal; and some deposits north of Arvida.

Sedimentary phosphate beds are fairly common in the Rocky Mountains. Most of the exposures occur along the Alberta-British Columbia border between the International Boundary and Banff. Beds at the base of the Fernie shale have received considerable attention during recent years.

Canadian phosphate industry

Elemental phosphorus. Elemental phosphorus is produced in Canada by the thermal reduction method which involves the smelting of phosphate rock with carbon (coke) and a siliceous flux. Coproducts of the process are ferrophosphorus, carbon monoxide and calcium silicate slag. About 9 tons of phosphate rock grading 66-68 per cent BPL are required to manufacture 1 ton of phosphorus. Although elemental phosphorus can be used for making fertilizers, it is generally used in the manufacture of chemicals, insecticides, detergents and other industrial compounds.

Table 1. Canada, phosphate rock imports and consumption, 1971-72

	1971		1972[p]	
	(short tons)	($)	(short tons)	($)
Imports				
United States	2,839,070	16,835,000	3,001,933	17,997,000
Netherlands Antilles	5,383	283,000	6,499	243,000
Total	2,844,453	17,118,000	3,008,432	18,240,000
	1970		1971	
Consumption[1] (available data)				
Fertilizers, stock and poultry feed	1,663,773		1,780,830	
Chemicals	225,522		232,513	
Other[2]	7,389		17,946	
Total	1,896,684		2,031,289	

Source: Statistics Canada.
[1]Breakdown by Mineral Resources Branch. [2]Includes amounts for refractories, food processing, medicinals and pharmaceuticals.
[p]Preliminary.

Table 2. Canada, phosphate rock imports and consumption, 1963-72

	Imports	Consumption
	(short tons)	
1963	1,297,427	1,166,573
1964	1,406,424	1,448,571
1965	1,695,296	1,606,915
1966	2,181,341	1,735,488
1967	2,279,767	2,275,095
1968	2,349,980	2,234,259
1969	2,201,331	1,822,069
1970	2,470,050	1,896,684
1971	2,844,453	2,031,289
1972[p]	3,008,432	..

Source: Statistics Canada.
[p]Preliminary; .. Not available.

Phosphate fertilizers. Phosphate fertilizers are normally produced by decomposing phosphate rock with a strong mineral acid. In Canada, only the two most common acidulants, sulphuric acid and phosphoric acid, are used in commercial practice; the former is by far the most common.

When phosphate rock is treated with sulphuric acid, either single superphosphate or phosphoric acid (correctly named orthophosphoric acid, H_3PO_4) is produced. For the former, the rock is treated with sufficient acid to convert the tricalcium phosphate into water-soluble monocalcium phosphate; the copro-

Table 3. World production of phosphate rock, 1970-72

	1970	1971	1972[e]
	('000 metric tons)		
United States	35,143	35,277	38,465
U.S.S.R.[1]	17,950	19,866	..
Morocco	11,399	12,013	12,701
Tunisia	3,024	3,162	3,266
China, People's Rep.	1,700	2,200	..
Nauru Island	2,114	1,867	..
Togo	1,508	1,715	1,814
Senegal	1,128	1,543	1,633
South Africa	1,247	1,226	..
Christmas Island	1,089	991	..
Israel	880	900	..
Ocean Island	506	620	..
Egypt	537	600	..
Algeria	500	555	..
North Vietnam	457	550	..
Jordan	891	528	..
Other countries	1,037	1,081	36,287
Total	81,110	84,694	94,166

Sources: The British Sulphur Corporation Ltd., Statistical Supplement November/December 1972, for 1970-71; U.S. Bureau of Mines Commodity Data Summaries, January 1973 for 1972.
[1]Includes other East European countries.
[e]Estimates; .. Not available.

Table 4. Canada, phosphorus and phosphate fertilizer plants, 1972

Company	Plant Location	Annual Capacity	Principal End Products	Basis for H_2SO_4 Supply for Fertilizer Plants
		(st)		
Elemental phosphorus				
Electric Reduction Company of Canada, Ltd.[1]	Varennes, Que.	20,000	el ph	
	Long Harbour, Nfld.	80,000	el ph	
Total, elemental phosphorus		100,000		
Phosphate fertilizer		(P_2O_5 eq.)		
Belledune Fertilizer Limited[2]	Belledune, N.B.	125,000	am ph	SO_2 smelter gas
Canadian Industries Limited	Beloeil, Que.	28,000	ss	sulphur
	Hamilton, Ont.[3]		ss	sulphur
	Courtright, Ont.	80,000	am ph	SO_2 pyrrhotite, Copper Cliff
Cominco Ltd.	Kimberley, B.C.	128,000	am ph	SO_2 smelter gas
	Trail, B.C.	86,000	am ph	SO_2 smelter gas
Electric Reduction Company of Canada, Ltd.	Port Maitland, Ont.	190,000	H_3PO_4, ss ts, ca ph	sulphur
Green Valley Fertilizer & Chemical Co. Ltd.	North Surrey, B.C.	1,000	ss	SO_2 smelter gas, Trail
Imperial Oil Limited	Redwater, Alta.	140,000	am ph	sulphur
Northwest Nitro-Chemicals Ltd.	Medicine Hat, Alta.	60,000	am ph	sulphur
St. Lawrence Fertilizers Ltd.	Valleyfield, Que.	56,000	ts, am ph	SO_2 smelter gas
Sherritt Gordon Mines, Limited	Fort Saskatchewan, Alta.	45,000	am ph	sulphur
Simplot Chemical Company Ltd.	Brandon, Man.	..	am ph	
Western Co-operative Fertilizers Limited	Calgary, Alta.	65,000	am ph	sulphur
Total, phosphate fertilizer		1,004,000		

el ph Elemental phosphorus; P_2O_5 eq. Phosphorus pentoxide equivalent; am ph Ammonium phosphates; ss Single superphosphate; tx Triple superphosphate; ca ph Food supplement calcium phosphate. .. Not applicable, H_3PO_4 is made elsewhere.

[1]Electric Reduction Company changed its name to Erco Industries Limited, effective January 1, 1973. [2]Noranda Mines Limited acquired full ownership of Belledune Fertilizer, effective April 1, 1972. [3]CIL's Hamilton Works were closed early in 1972.

duct of the reaction, calcium sulphate, remains in the mixture. Normal raw material requirements to produce 1 ton of superphosphate, grading 20 per cent P_2O_5 equivalent, are 0.64 ton of phosphate rock (70-72 per cent BPL) and 0.47 ton of sulphuric acid (100 per cent basis).

To produce phosphoric acid, larger quantities of sulphuric acid are added to maintain a fluid slurry that facilitates removal of calcium sulphate by filtering. Off-stream acid, containing 30 to 32 per cent P_2O_5 equivalent, may be used either directly in the manufacture of phosphate fertilizers or concentrated by evaporation to as high as 54 per cent P_2O_5 equivalent prior to further use or sale as merchant acid. Typical raw material requirements for 1 ton of P_2O_5 equivalent produced are 3.1 tons of phosphate rock (74-75 per cent BPL) and 2.6 tons of sulphuric acid (100 per cent basis). Also, for every ton of P_2O_5 equivalent produced, about 4.5 tons of waste calcium sulphate are generated.

Most of the acid is then neutralized with ammonia to form ammonium phosphate fertilizers. Common grades are 16-20-0 (16 per cent N, 20 per cent P_2O_5 equivalent, and 0 per cent K_2O equivalent), 11-40-0 and 18-46-0. At some plants, phosphoric acid is used to acidulate phosphate rock, in which case the end product is triple superphosphate, normally grading 46 per cent P_2O_5 equivalent.

There are ten phosphoric acid plants in Canada with a combined annual productive capacity of

940,000 tons of P_2O_5 equivalent (see Table 4). The balance of Canada's P_2O_5 productive capacity, amounting to 64,000 tons annually, consists of plants that are capable of producing single and/or triple superphosphate. Early in 1972, Canadian Industries Limited closed its superphosphate plant at Hamilton, Ontario; the plant had been operating since 1931.

Production, trade and consumption. Nearly all Canada's trade in phosphate fertilizers is with the United States, mostly in areas where plants are close to farming communities in the neighbouring country. Under foreign aid programs, shipments are occasionally made to southeast Asian countries.

Preliminary figures indicate that production of phosphate fertilizers rose sharply to 745,767 tons

Table 5. Canada, phosphate fertilizer production, years ended June 30, 1963-72

	(short tons P_2O_5 equivalent)		(short tons P_2O_5 equivalent)
1963	299,453	1968	538,796
1964	353,547	1969	523,934
1965	374,159	1970	496,380
1966	461,608	1971	619,669
1967	533,460	1972p	745,767

Source: Statistics Canada.
pPreliminary.

Table 6. Canada, trade in selected phosphate products, 1971-72

	1971		1972p	
	(short tons)	($)	(short tons)	($)
Imports				
Calcium phosphate				
United States	21,978	2,335,000	27,010	2,833,000
Belgium and Luxembourg	359	20,000	–	–
Japan	308	17,000	–	–
Total	22,645	2,372,000	27,010	2,833,000
Fertilizers				
Normal superphosphate, 22% P_2O_5 or less				
United States	356	11,000	642	20,000
Triple superphosphate, over 22% P_2O_5				
United States	52,546	2,156,000	45,855	1,898,000
France	–	–	9	1,000
Total	52,546	2,156,000	45,864	1,899,000
Phosphatic fertilizer, nes				
United States	50,174	3,060,000	60,878	3,741,000
Britain	137	47,000	689	201,000
Other countries	23	2,000	92	16,000
Total	50,334	3,109,000	61,659	3,958,000
Chemicals				
Potassium phosphates				
United States	2,084	608,000	2,307	653,000
France	61	21,000	–	–
Total	2,145	630,000	2,307	653,000
Sodium phosphate tribasic				
United States	815	120,000	1,451	201,000
Belgium and Luxembourg	39	4,000	205	21,000
France	225	26,000	75	10,000
People's Republic of China	–	–	6	. . .
Total	1,079	150,000	1,737	232,000

Table 6 (concl'd)

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Sodium phosphate, nes				
United States	4,887	1,207,000	5,413	1,196,000
West Germany	50	12,000	94	28,000
Britain	1	1,000	5	3,000
Total	4,938	1,220,000	5,512	1,227,000
Exports				
Nitrogen phosphate fertilizers				
United States	599,939	36,322,000	614,215	37,689,000
India	75,105	4,205,000	51,423	2,960,000
Lebanon	–	–	16,212	690,000
Belgium and Luxembourg	–	–	11,576	492,000
New Zealand	–	–	5,612	330,000
Britain	2,316	144,000	2,701	171,000
Brazil	–	–	2,235	133,000
Pakistan	13,306	907,000	–	–
Italy	12,125	708,000	–	–
France	3,498	217,000	–	–
Total	706,289	42,503,000	703,974	42,465,000

Source: Statistics Canada.
^{p}Preliminary; – Nil; nes Not elsewhere specified; . . . Less than $1,000.

Table 7. Canada, phosphate fertilizer consumption and trade, years ended June 30, 1963-72

	Consumption	Imports[1]	Exports
	(short tons P_2O_5 equivalent)		
1963	223,314	44,443	101,890
1964	264,245	86,279	102,842
1965	293,758	66,604	97,207
1966	367,591	65,498	126,524
1967	412,214	73,936	138,133
1968	440,093	43,726	165,048
1969	347,813	24,054	161,051
1970	309,400	11,293	218,501
1971	359,781	11,421	338,779
1972^p	374,097	21,045	300,705

Source: Statistics Canada.
[1]Excludes nutrient content of mixtures and of orthosphoric acid.
^{p}Preliminary.

P_2O_5 equivalent in the fertilizer year 1971/72, up 20 per cent from the previous twelve months. Exports were off by 11 per cent to 300,705 tons P_2O_5 equivalent in the fertilizer year 1971/72 and although domestic consumption was up slightly to 374,097 tons P_2O_5 equivalent, it remained well below the peak of 538,796 tons recorded in 1967/68. The foregoing figures imply that there was a large carryover in stockpiles at June 30, 1972.

Outlook

The short- and long-term prospects for Canada's phosphate fertilizer industry are favourable. Although raw material prices are rising and are expected to rise further during the next few years, strong demand for farm products both in North America and abroad is likely to lead to substantially higher farm incomes, the implication being that higher fertilizer prices can be passed along to the consumer. Raw material prices are rising on two fronts: phosphate rock and natural gas. Demand for phosphate rock was somewhat sluggish during 1970-71 and prices weakened; the current surge in world demand led to firm prices in 1972 and some increases in listed prices for phosphate rock can be anticipated for 1973 and 1974. Prices for natural gas, which is the key raw material used in North America to manufacture ammonia for the preparation of ammonium phosphate fertilizers, have also been on the increase and most predictions call for much larger increases during the remainder of the 1970's. Sulphur, the third key raw material for phosphate fertilizer, is in abundant supply and is likely to be available at fairly low prices for the foreseeable future.

Domestic consumption for the fertilizer year 1972/73 is expected to reach the 1967/68 high and with continuing strong export demand, production will be up sharply and producers' inventories will be virtually depleted by the end of June 1973.

Prices and tariffs

Phosphate rock prices are based upon the BPL content. Maximum limits of moisture, iron and alumina are specified and bonuses are paid and penalties assessed for variations above and below the base grade. Although much phosphate rock is supplied on a contract basis, price quotations serve as a reliable guide. Prices for phosphate fertilizers are usually based on the unit content or minimum analysis of the P_2O_5 equivalent, commonly expressed as an available phosphoric acid (apa).

The December 25, 1972 issue of *Chemical Marketing Reporter* listed the following prices (a unit-ton is 2,000 pounds of 1 per cent of the basic constituent or other standard of the material. The percentage figure of the basic constituent multiplied by the price shown in CMR gives the price of 2,000 pounds of the material).

	($)
Phosphate rock, Florida land pebble, run-of-mine, unground, bulk, carlots, fob mines, per short tons	
(%BPL)	
66-68	6.50
68-70	5.84-7.50
70-72	6.50-8.15
74-75	7.55-9.20
76-77	10.20
Defluorinated phosphate, feed grade, 100-lb bags, carlots, fob Coronet, Fla., freight equalized, 19 per cent P, per short ton	72.25
Phosphoric acid, agricultural grade, fob works, per unit-ton, 52-54 per cent apa	1.00 - 1.05
Superphosphate, run-of-pile, pulverized, bulk, carlots, fob works, per unit-ton, under 22 per cent apa	.80 - .95

The price listings, which remained essentially unchanged from the past four years, closely reflected realized prices whereas in the previous two years some price cutting had taken place. Phosphate rock and phosphate fertilizer materials enter Canada and the United States duty free.

Platinum Metals

C.J. CAJKA

The platinum group metals, also referred to as the platinoids, consist of platinum, palladium, rhodium, iridium, ruthenium and osmium. The U.S.S.R., Republic of South Africa and Canada, ranked in decreasing order of production volume, are the major producers of platinoids. Colombia, the United States, Japan and Ethiopia have a small output.

Platinoids are found in nature associated with basic and ultrabasic rocks and in placer deposits. A large quantity of platinum metals is recovered as a by-product of nickel-copper refining, but a major portion of world production comes from mines worked principally for platinoids, notably in South Africa.

Most producers increased capacity rapidly during the 1960's. South African producers expanded their facilities because of a short supply during the sixties and an anticipated growth in demand in the seventies. Canadian capacity increased because platinoids are a byproduct of nickel-copper refining and Canadian nickel-copper processing facilities have undergone major expansion during the past few years.

Plentiful supplies were available from 1970 to 1972; anticipated growth in demand did not materialize, primarily because the automobile industry remained uncommitted to using platinum-based catalytic converters in new automobiles. This last application was expected to be a major new market for platinum. Subsequently, South African producers reduced output and curtailed new developments. Canadian production, tied to nickel output, declined at the same time. As a result of increased production capacity and a slow growth in demand, there has been, since 1970, excess capacity in the industry.

Canadian production of platinum metals in 1972 was 399,000 troy ounces valued at $33,854,000, a decrease from 475,169 troy ounces valued at $39,821,616 in 1971. Output declined mainly because The International Nickel Company of Canada, Limited (INCO) effected the third stage of a 3-phase program to reduce output. INCO had accumulated a large stock of nickel inventories in 1971 when nickel sales declined and the company proceeded to correct this imbalance by production cut-backs. As Canadian platinum metals production was directly related to nickel output, a decline in platinum metals production followed.

World platinum group metals production in 1972 was estimated at 4,359,000 troy ounces, an increase of almost 7 per cent over 1971. World production declined in 1971 but recovered in 1972, largely because of production adjustments in South Africa. In 1972, the U.S.S.R. accounted for 2.4 million ounces, Republic of South Africa for 1.5 million ounces, Colombia for 25,000 ounces and the United States for 19,000 ounces.

Production

Canada: The platinum metals recovered in Canada are extracted from nickel-copper sulphide ores, principally those of Sudbury, Ontario and the Thompson-Wabowden region of Manitoba. The platinoids concentrate in a nickel-copper alloy and sulphide matte from the smelting process. After the smelter products undergo further processing and, finally, electrolysis, the platinoids collect in the electrolytic tank residues. These residues are refined to the metal stage in offshore refineries. With the start-up of INCO's new nickel refinery at Sudbury in 1973, platinoid-bearing concentrate, derived from a residue following the selective extraction of nickel in the carbonyl process, will be recovered. INCO ships platinum metals residues, following some additional purification, to its refinery at Acton, England. Falconbridge Nickel Mines Limited ships nickel-copper matte to its refinery in Kristiansand, Norway. Platinoid-bearing sludge from the latter plant is sent to Engelhard Minerals & Chemicals Corporation at Newark, New Jersey, for final refining. The nickel refining processes used by Sherritt Gordon Mines, Limited and Texmont Mines Limited, the only other Canadian producers of refined nickel, do not lend themselves to the economic recovery of the platinum metals.

During 1971, world demand for nickel declined with the result that producers' inventories accumulated to an undesirable level. INCO reacted to the unfavourable nickel market by announcing production cut-backs to reduce nickel output about 20 per cent by February of 1972. Operations were suspended at Creighton No. 3 shaft, Crean Hill mine, Coniston smelter, and the Creighton mill as the final phase of the scheduled curtailment. Falconbridge also announced plans to reduce nickel output in 1972 by 5 per cent.

In the Sudbury area of Ontario, INCO operated twelve nickel-copper mines, five concentrators, and two smelters in 1972. The company is readying its

Table 1. Canada, platinum metals production and trade, 1971-72

	1971		1972^p	
	(troy ounces)	($)	(troy ounces)	($)
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	475,169	39,821,616	399,000	33,854,000
Exports				
Platinum metals in ores and concentrates				
Britain	201,478	21,938,000	541,193	28,561,000
Norway	12,003	1,153,000	14,985	1,439,000
United States	–	–	101	4,000
Total	213,481	23,091,000	556,279	30,004,000
Platinum metals				
United States	7,043	464,000	18,343	1,103,000
Britain	3,638	336,000	1,180	125,000
Jamaica	29	4,000	13	2,000
Mexico	605	22,000		–
Total	11,315	826,000	19,536	1,230,000
Platinum metals in scrap				
United States	13,602	1,160,000	22,954	1,965,000
Britain	13,722	1,384,000	16,079	1,951,000
Total	27,324	2,544,000	39,033	3,916,000
Re-Exports[2]				
Platinum metals, refined and semiprocessed	35,523	3,185,000	33,376	4,542,000
Imports				
Platinum lumps, ingots, powder and sponge				
Britain	7,016	887,000	5,202	671,000
United States	1,048	127,000	–	–
Total	8,064	1,014,000	5,202	671,000
Other platinum group metals in lumps, ingots, powder and sponge				
Britain	33,051	1,804,000	26,306	1,534,000
South Africa	11,727	431,000	15,300	628,000
United States	766	49,000	911	25,000
Total	45,544	2,284,000	42,517	2,187,000
Total platinum and platinum group metals				
Britain	40,067	2,691,000	31,508	2,205,000
United States	1,814	176,000	911	25,000
South Africa	11,727	431,000	15,300	628,000
Total	53,608	3,298,000	47,719	2 858,000
Platinum crucibles				
United States	22,195	3,531,000	29,835	4,685,000
Britain	53	7,000	4	. . .
Total	22,248	3,538,000	29,839	4,685,000
Platinum metals, fabricated materials, not elsewhere specified				
Britain	14,397	1,862,000	29,941	2,918,000
United States	5,030	291,000	11,592	270,000
Total	19,427	2,153,000	41,533	3,188,000

Source: Statistics Canada.
[1] Platinum metals, content of concentrates, residues and matte shipped for export. [2] Platinum metals, refined and semiprocessed, imported and re-exported after undergoing no change or alteration.
^{p}Preliminary; – Nil; . . . Less than one thousand dollars.

Table 2. Canada, platinum metals, production and trade, 1963-72

	Production[1]		Exports				Imports[4]	
			Domestic[2]		Re-export[3]			
	oz.	$	oz.	$	oz.	$	oz.	$
1963	357,651	22,585,205	549,627	24,555,816	386,941	10,144,484	..	13,590,575
1964	376,238	25,404,117	408,792	20,812,514	581,779	20,888,749	221,557	17,369,291
1965	463,127	36,109,799	551,022	30,103,254	321,950	11,389,395	233,603	13,461,546
1966	396,059	32,370,064	441,625	25,800,000	199,152	11,779,822	197,853	14,930,000
1967	401,263	34,668,915	475,855	29,829,000	164,033	9,087,955	212,889	13,161,000
1968	485,891	46,199,718	584,942	38,068,000	83,228	8,254,753	207,961	17,077,000
1969	310,404	30,881,016	463,500	35,306,000	52,694	5,247,240	118,946	9,300,000
1970	482,428	43,556,597	650,066	43,174,000	20,399	2,365,735	60,745	3,123,000
1971	475,169	39,821,616	224,796	23,917,000	35,523	3,185,000	53,608	3,298,000
1972^p	399,000	33,854,000	575,815	31,234,000	33,376	4,542,000	47,719	2,858,000

Source: Statistics Canada.
[1]Platinum metals, content of concentrates, residues and matte shipped for export. [2]Platinum metals in ores and concentrates and platinum metals, refined. [3]Platinum metals, refined and semi-processed, imported and re-exported after undergoing no change or alteration. [4]Imports, mainly from Britain, of refined and semi-processed platinum metals, derived from Canadian concentrates and residues, a large part of which is re-exported.
^{p}Preliminary; . . Not available.

new nickel refinery for production in early 1973 and is developing a new mine for start-up in 1976. One new mine and concentrator, located at Shebandowan in northwestern Ontario, was brought to production in 1972. Elsewhere in Ontario, INCO operated a nickel refinery at Port Colborne.

Falconbridge Nickel Mines operated eight nickel-copper mines, four concentrators and one smelter in the Sudbury region. The company has deferred developments on other new mines in the area. Consolidated Canadian Faraday Limited, with a mine in western Ontario, shipped copper-nickel concentrate to the INCO smelter in Sudbury. When ore reserves were depleted in August 1972, Consolidated Canadian Faraday closed its mine but continued to mill ore from the Dumbarton mine. The Langmuir nickel mine, a joint Noranda Mines Limited – INCO project near Timmins, is scheduled for production in 1973.

In Quebec, Renzy Mines Limited temporarily suspended production at its Hainault Township open-pit mine in April 1972 when the smelter contract with Falconbridge was terminated. The company plans to dewater the open pit in 1973 but alternative markets for its nickel-copper concentrate have not been established.

Three companies mined nickel-copper ores in Manitoba. INCO operated three mines and a concentrator-smelter-refining complex in the Thompson region. Production at the company's Birchtree mine was reduced during 1972 and the Soab mine, closed in 1971, was maintained on standby basis. Falconbridge Nickel operated a mine and concentrator at Wabowden and shipped the mine's output to its smelter in Falconbridge. Dumbarton Mines Limited, located in the Bird River area of Manitoba, shipped ore to the Consolidated Canadian Faraday mill and its concentrate was shipped to the Falconbridge smelter. With the closing of the Consolidated Canadian Faraday mine, Dumbarton expanded mine production from 800 to 1,100 tons a day.

U.S.S.R.: Platinoids in the U.S.S.R. are derived mainly from nickel deposits in basic and ultrabasic rocks of the Norilsk region of Siberia and the Kola Peninsula of northwest Russia. Also, small amounts of platinum are recovered from placer deposits in the southern Urals. Russian production in 1972 was estimated at 2.4 million ounces, an increase from 2.3 million ounces estimated for 1971. A major two-phase expansion program to increase nickel output has been undertaken, the first to be completed by 1975 and the second in 1980.

South Africa: Producers in the Republic of South Africa, the noncommunist world's largest supplier of platinum metals, were expanding capacity when, in 1970, platinum came into oversupply. In addition to suspending developments, production rates were also reduced. Most capacity and production data given below refer to platinum only. South African ores contain approximately 2 troy ounces of palladium for every 5 ounces of platinum.

The noncommunist world's largest platinum producer, Rustenburg Platinum Mines Limited, operated three mines, a smelter and a refinery in the Transvaal district. During 1972, several automobile manufacturers announced commitments to use platinum and palladium in catalytic converters to meet the 1975 Environmental Protection Agency (EPA) standards for automobile exhaust emissions in the United States. These encouraging announcements, as well as a preliminary agreement to supply Engelhard Minerals & Chemicals Corporation with 1,500,000 ounces of platinum for Ford Motor Company's 1975-1977 automobiles, were undoubtedly an important influence in the decision to resume expansion and to increase capacity to 1.3 million ounces of platinum a year by the end of 1973. In line with this expansion, Rustenburg is developing the Amandelbutt mine, which will have an initial annual capacity of 225,000 ounces of platinum. Rustenburg acquired the Brakspruit mine, formerly owned by the Brakspruit Consortium, in 1972. The Brakspruit mine has a contract to supply Engelhard with 300,000 ounces of platinum a year.

Impala Platinum Limited operated a mine-mill-refinery complex near Rustenburg. Capacity at the operation is about 350,000 ounces of platinum a year. The company has announced plans to increase capacity to 450,000 ounces in 1973 and to 750,000 ounces by 1975. Impala has negotiated a contract to supply General Motors Corporation with 300,000 ounces of platinum and 120,000 ounces of palladium each year, for a period of ten years, beginning in 1974.

Western Platinum Limited, a Lonrho Limited-Falconbridge Nickel-Superior Oil Company joint venture in the Rustenburg region, began production at its Middlekraal mine and mill in 1971. Production from the smelter began in December of 1971. Smelter matte, which contains copper, nickel and platinoids, is shipped to Falconbridge's refinery in Norway and platinum metals-bearing residues are processed at PGP Industries, Los Angeles. The refining agreement with PGP Industries for associated metals as well as about 80,000 ounces of platinum a year, extends to April, 1974 or until Western Platinum arranges for its own refinery, whichever occurs last. A refinery to recover platinum, palladium and gold is under construction at Brakpan, Transvaal. When the new refinery, scheduled for completion in 1974, is operational, Western Platinum is expected to have an annual output of 120,000 to 140,000 ounces of platinum and 80,000 to 90,000 ounces of other platinoids and gold.

United States: Mine production of the platinoids in the United States was from placer deposits in the Goodnews Bay area of Alaska. Some primary production was obtained as a byproduct of gold and copper refining.

Colombia: Production in Colombia, amounting to about 25,000 ounces in 1972, was obtained from placers in the Choco district.

Others: During 1971, interesting discoveries of platinoid mineralization were reported in Australia, New Zealand and Greenland. Commercial development has not been announced for any of these.

Uses

Platinoids have several applications in industry because of their many special properties, the principal ones being catalytic activity, resistance to corrosion, resistance to oxidation at elevated temperatures, high melting point, high strength and good ductility. Platinum and palladium are the major platinum metals; iridium, osmium, ruthenium and rhodium are used mainly as alloying elements to modify properties of platinum and palladium. Rhodium is also used in plating.

The catalytic action of platinum, palladium, rhodium and ruthenium is utilized in the petroleum industry for the production of high octane gasolines; in the chemical industry for the production of sulphuric and nitric acids, and the hydrogenation of organic chemicals; and the drug industry for the manufacture of pharmaceuticals, vitamins and antibiotics. A recent development is the use of platinum metal salt and complexes as homogeneous catalysts for the oxidation, isomerization, hydrogenation and polymerization of olefins.

A major new application for platinum and palladium is in automobile catalytic reactors to meet new exhaust emission standards. Platinoid-based catalytic reactors are said to contain about 0.1 ounce of platinum for each automobile. Some reactors are to contain 30 per cent palladium in combination with platinum. Platinum is currently used on a limited scale in emission control systems where clean exhausts are absolutely essential. Following the introduction of platinoid-based exhaust control systems, lead-free fuels will be required because lead poisons platinoid catalysts. The production of lead-free gasoline requires more reforming and thereby places a greater demand on platinum catalysts in the petroleum industry. A further outcome of pollution abatement legislation is the application of a palladium catalytic system to treat nitric acid plant waste gases.

The corrosion resistance of the platinum metals is utilized in laboratory utensils to contain corrosive liquids and as protective coatings for vessels used in the melting of materials for laser crystals. Wear resistance of the platinum metals makes them ideal for use as spinnerets in the production of glass and synthetic fibres. Platinum and platinum alloys are used for the cathodic protection of ship's hulls and as inert anodes in electro-deposition. Palladium is used as contacts in automatic electric switching gear and in dentistry. Wear resistance and beauty of finish are the qualities that create a demand for the platinum metals in the manufacture of high-quality jewelry.

Iridium is used primarily as a hardening additive in platinum and palladium alloys for use in the jewelry

Table 3. World production of platinum group metals

	1970 (troy ounces)	1971 (troy ounces)	1972[e] (troy ounces)
U.S.S.R.	2,200,000	2,300,000	2,400,000
Republic of South Africa	1,502,800	1,250,000	1,500,000
Canada	482,428	475,169	399,000
Colombia	26,358	26,000	25,000
United States	17,385	18,000	19,000
Other countries	8,178	15,000	16,000
Total	4,237,149	4,084,169	4,359,000

Sources: US Bureau of Mines, Minerals Yearbook, 1970; US Bureau of Mines, Commodity Data Summaries, January 1973, for 1971 and 1972.
[e]Estimate.

industry, in electrical contacts and components for chemical manufacture, and in high-purity iridium crucibles for growing laser crystals and synthetic gemstones. More recently, it was reported that a new use has been found for iridium as a catalyst for petroleum refining.

The principal uses of osmium are in chemical, dental and medical application. Rhodium is used mainly in jewelry and chemical applications and ruthenium finds its principal use in the chemical industry.

Outlook

The short term outlook for platinum and palladium has dramatically reversed from one year ago as a result of automotive firms having announced their intentions of going the platinum metals way for their exhaust emissions control devices. Idle capacity and deferred expansion programs, mainly in South Africa, are being reactivated to supply this large new market. Noncommunist world production capacity in 1972 reached approximately 1.7 million ounces of platinum and, if U.S.S.R. exports, are included, a potential annual supply of 2.1 million ounces was indicated for 1972. By 1975 supply could reach 3.1 million ounces. Consumption of platinum varies widely but it is estimated that the noncommunist world uses about 1.5 million ounces a year, exclusive of demand in automobile exhaust controls. The automotive industry may consume some 1 million ounces of platinum metals annually.

The medium term is still somewhat in doubt. On the positive side, a number of users have signed long term supply contracts: an agreement between Rustenburg, Engelhard and the Ford Motor Company to provide up to 380,000 ounces of platinum and 120,000 ounces of palladium a year for the 1975-77 model years and up to 360,000 ounces of platinum and 144,000 ounces of palladium for the 1978-79 models; an agreement between Engelhard and AB Volvo for 100,000 ounces of platinum each year for the 1976-78 model years; a 5-year supply contract between Western Platinum and Mitsubishi for 65,000 – 70,000 ounces of platinum and about one third this amount of palladium, with deliveries starting in January 1974; a U.S.S.R-Chrysler Corporation contract for 100,000 ounces of palladium to be delivered in 1973; an Impala-General Motors Corporation agreement to supply annually 300,000 ounces of platinum and 120,000 ounces of palladium for the 10-year period 1974-83. There are other letters of intent and several smaller supply agreements. The prospects for rapid growth in demand are dampened by the ever present threat of substitution for platinoids in automobile emission control devices and new developments which would allow the use of substantially smaller quantities of the platinoids. Somewhat further into the future, engine modification and new engine designs, which may be perfected over the next few years, might make catalytic reactors unnecessary.

When platinum-based catalytic reactors are introduced by the automotive industry, the demand for lead-free gasoline will grow rapidly because lead fouls these catalysts. A suitable lead-free fuel can be made by additional reforming with platinum-ruthenium catalysts but, to meet the demand, refineries must install more reforming capacity.

During April, 1973, the United States Environmental Protection Agency announced a one year postponement of the 1975 automobile emissions standards set forth by the Clean Air Act of 1970. The new schedule calls for 1975 nationwide interim standards not exceeding 1.5 grams of hydrocarbons and 15 grams of carbon monoxide per vehicle-mile and, for California, 0.9 gram of hydrocarbons and 9 grams of carbon monoxide per mile. The interim standards were set to phase in catalytic systems in 1975; all California vehicles and some nationwide models will have to be equipped with catalysts to meet the revised 1975 standards. Canada has proposed emission control standards for 1975, but, being less stringent than the United States equivalents, the Canadian standards will not necessitate the use of catalytic converters. Under the Canadian proposal, hydrocarbon emissions are to be reduced to 2 grams and carbon monoxide to 25 grams per vehicle-mile. Neither the U.S. revision nor the proposed Canadian standards is likely to have a serious disrupting effect on the platinum metals market.

Prices

Price strengthening was observed for four of the platinum metals during 1972. These price changes are illustrated in the accompanying table. The table shows that dealers' prices moved over a wide range while producers' prices remained relatively stable. A certain amount of speculation is indicated by dealers' quotations whereas producers' prices reflect large producer inventories and the producers' desire to maintain price stability.

Both platinum and palladium moved higher on the strength of commitments by the automotive industry to use these two metals in emissions control devices. Also, platinum was used as a hedge against inflation and losses associated with international monetary problems. The dealer price of iridium moved spectacularly from the $145 range in January to $525 an ounce in May. Iridium became scarce on the open market early in the year; it was reported that large quantities of iridium were committed for use in a new petroleum catalyst. By year-end, the dealer price of iridium subsided to the $275 – $300 range. Interest in ruthenium, a substitute for iridium in many applications, increased during the year. The dealers' price for ruthenium moved from $45 an ounce in the first half of the year to the $60 range by December, 1972.

	Producers	Dealers
	(U.S. $ per troy ounce)	
Iridium		
January 1 – February 2	150-155	145-148
February 3 – May 24	150-155	195-525
May 25 – June 25	150-155	475
June 26 – August 23	150-195	475
August 24 – October 11	150-195	350-400
October 12 – December 31	150-195	275-300
Osmium		
January 1 – August 16	200-225	175-200
August 17 – December 31	200-225	150-175
Palladium		
January 1 – February 2	36-38	36-37
February 3 – June 21	36-38	35.5-36.0
June 22 – June 25	36-38	39.25-40.25
June 26 – August 16	38-41	40.25-54.0
August 17 – October 1	38-52	52-62
October 2 – November 1	38-60	62.5-69
November 2 – November 19	60-61	66-68
November 20 – November 29	68-69	68-70
November 30 – December 31	68-70	67-72
Platinum		
January 1 – January 16	120-125	104-116
January 17 – May 17	110-120	102-105
May 18 – June 5	110-120	104-120
June 6 – July 16	120-125	128-152
July 17 – August 24	130-135	145-160
August 25 – December 31	130-135	129-157
Rhodium		
January 1 – December 31	195-200	195-198
Ruthenium		
January 1 – August 9	50-55	45
August 10 – September 27	50-55	55-58
September 28 – December 31	50-55	58-60

Source: Based upon *Metals Week*.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
36300-1	Platinum wire and platinum bars, strips, sheets, or plates; platinum, palladium, iridium, osmium, ruthenium and rhodium, in lumps, ingots, powder, sponge or scrap	free	free	free
48900-1	Crucibles of platinum, rhodium and iridium and covers therefore	free	free	15%

Tariffs (cont'd)

United States

Item No.				
601.39	Precious metal ores	free		
605.02	Platinum metals, unwrought, not less than 90% platinum	free		

		On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(%)	(%)	(%)
605.03	Other platinum metals, unwrought	28	24	20
605.05	Alloys of platinum, semimanufactured, gold-plated	35	30	25
605.06	Alloys of platinum, semimanufactured, silver-plated	16.5	14	12
605.08	Other platinum metals, semimanufactured, including alloys of platinum	28	24	20

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

Potash

W.E. KOEPKE

World potash production and consumption continued a strong upward trend in 1972 but demand for Saskatchewan potash was sluggish, particularly in the last half of the year. With the exception of Canada and the U.S.S.R., which has experienced transportation and distribution problems in moving potash from its mines to marketing outlets, producer inventories have declined from a 1968 peak to the extent that stocks in western Europe are virtually nonexistent. An already tight supply situation in western Europe was further aggravated by a labour dispute that kept the French potash mines idle from mid-October to mid-December 1972. The temporary shortage in Europe opened the door for a further sale in early 1973 of 60,000 tons of Saskatchewan potash to the French sales organization. The 60,000 tons is in addition to a 1971 three-year contract that called for the delivery of 180,000 tons of K_2O annually. In view of a continuing tight supply situation in Europe that extends to some other world markets, the outlook for Saskatchewan potash in 1973 is favourable. Many world buyers are, however, viewing Saskatchewan as a residual supplier and only when shortages develop elsewhere in the world, can the Saskatchewan producers be assured of picking up orders for extra tonnage to fill localized demand-supply gaps.

For the third consecutive year, the Saskatchewan government controlled production under the Potash Conservation Regulations, 1969, and all sales were subject to a floor price of 33.75¢ per unit of K_2O. The control program, which has restrained Saskatchewan output to about one half the industry's nominal capacity, has been largely responsible for maintaining a relative balance between total world supply and demand, and firm prices in North American and international seaborne markets.

On July 1, 1972, the first major revisions were put into effect governing the issuing of production licences under the regulations. The initial licensing system, assigned on a quarterly basis, consisted of a three-part proration formula providing a basic allowable of 40 per cent of installed productive capacity, a market requirement allowable depending largely upon past sales performance, and an inventory allowable. The market requirement allowable could be enlarged upon application for supplementary licences. Under the revised system, the Saskatchewan Department of Mineral Resources, in conjunction with the industry, estimates market demand for the forthcoming fertilizer year (July 1 to June 30) and allocates 12-month production quotas according to productive capacity. Market demand for Saskatchewan potash for 1972-73 was estimated at 4.4 million tons K_2O equivalent. In practice, only 95 per cent of the estimated market demand is allocated, the balance to be taken from producer inventories as required. In addition, inventory allowables are granted at the discretion of the department. Actual administration of the regulations is through a three-member Potash Conservation Board.

The revised technique of issuing production licences prompted Central Canada Potash Co. Limited to take court action against the legality of assigning production quotas. Using the supplemental licence procedure provided under the initial system, Central Canada Potash by virtue of its so-called captive outlets was able to obtain allowables that gave it a 72 per cent operating rate for 1971-72 compared with an industry average of about 48 per cent; the revised method gives Central Canada Potash an operating rate of 49 per cent for 1972-73, a rate that applies to all other producers subject to differences in inventory needs. Central Canada's challenge has involved two cases: the first entailed a writ of mandamus against the Saskatchewan government's method of issuing production licences filed in the Court of the Queen's Bench, Saskatoon, in July 1972. Following a refusal in the lower court, an appeal was filed in October before the Saskatchewan Supreme Court of Appeal and it was also rejected. In late November an appeal case was filed before the Supreme Court of Canada and it was rejected in February 1973. The writ sought a court decision that would have compelled the Saskatchewan government to issue a larger production quota to the company. In a second case, on December 11, 1972, in the Court of the Queen's Bench, Saskatoon, Central Canada Potash filed a $2-million claim of damages from the Minister of Mineral Resources and the Saskatchewan government. The claim also seeks a declaration that the production and price control program is beyond the legislative authority of the province.

Production and developments in Canada

Saskatchewan. According to the Saskatchewan Department of Mineral Resources, production of potash in the province in 1972 was 4,329,457 tons K_2O equivalent and sales totalled 4,082,428 tons. Produc-

Table 1. Canada, potash production, shipments and trade, 1971-72

	1971		1972[p]	
	(short tons)	($)	(short tons)	($)
Production, potassium chloride				
Gross weight[1]	6,441,000		7,082,000	
K_2O equivalent	3,938,489		4,329,457	
Shipments				
K_2O equivalent	3,999,511	134,955,000	4,130,000	140,500,000
Imports, fertilizer potash				
Potassium chloride				
United States	62,891	1,801,000	69,120	1,699,000
West Germany	12	4,000	15	5,000
Total	62,903	1,805,000	69,135	1,704,000
Potassium sulphate				
United States	14,562	608,000	20,517	862,000
Potash fertilizer, nes				
United States	15,228	386,000	28,833	628,000
Potash chemicals				
Potassium carbonate	1,249	217,000	1,211	217,000
Potassium hydroxide	997	236,000	1,812	365,000
Potassium nitrate	3,193	348,000	6,105	656,000
Potassium phosphate	2,145	630,000	2,307	653,000
Potassium bitartrate	76	48,000	69	48,000
Potassium silicates	974	190,000	916	174,000
Total, potash chemicals	8,634	1,669,000	12,420	2,113,000
Exports, fertilizer potash				
Potassium chloride				
United States	4,311,292	102,074,000	4,666,454	107,291,000
Japan	645,554	15,416,000	627,068	15,027,000
Belgium-Luxembourg	76,273	1,659,000	201,570	4,741,000
India	313,880	7,338,000	191,903	4,641,000
Brazil	72,326	2,230,000	156,427	4,039,000
South Korea	102,265	2,130,000	146,547	3,388,000
Australia	91,278	2,229,000	95,395	2,140,000
New Zealand	119,003	3,012,000	62,958	1,568,000
Singapore	39,287	930,000	47,659	1,206,000
Taiwan	31,586	785,000	32,749	995,000
Malaysia	5,502	145,000	42,406	820,000
Other countries	200,801	4,531,000	66,790	1,627,000
Total	6,009,047	142,479,000	6,337,926	147,483,000

Source: Statistics Canada; Saskatchewan Department of Mineral Resources for K_2O production figures.
[1] Based on a conversion factor of $K_2O \times 1.64$ for standard, special standard, granular and coarse grades, and $K_2O \times 1.60$ for soluble and chemical grades.
[p] Preliminary.

tion was up from 3,938,489 tons in 1971 and sales volume was up slightly from 3,974,843 tons. The value of potash sales according to the Saskatchewan Department of Mineral Resources amounted to $146 million in 1972, unchanged from the previous year. Producer stocks at the end of 1972 stood at an all-time high of 1,146,746 tons K_2O equivalent, up sharply from the previous year's level of 826,615 tons; stocks at the end of 1970 totalled 959,479 tons.

As indicated in Table 4 there are ten potash mines

Table 2. Canada, potash production and sales by grade[1] and destination, 1971-72

	1972							
	Standard	Special Std.	Coarse	Granular	Soluble	Chemical	Total	1971
	(short tons of K_2O equivalent)							
Production	1,064,304	334,862	1,477,880	994,638	384,036	73,737	4,329,457	4,082,428[r]
Sales								
Domestic	38,676	216	155,976	17,456	6,797	279	219,400	177,206
United States	585,208	14,590	1,109,952	776,559	229,821	74,815	2,790,945	2,748,485
Offshore								
Australia	10,351	–	31,071	13,512	–	–	54,934	54,254
Belgium	29,145	76,560	–	30,082	–	–	135,787	77,423[r]
Brazil	–	–	60,379	27,700	–	–	88,079	47,527
China, P.R.	18,025	–	–	–	–	–	18,025	–
Colombia	–	–	–	–	–	–	–	2,957
England	–	(184)	–	–	–	884	700	24,404
France	–	–	6,768	6,682	–	–	13,450	–
West Germany	–	–	–	–	–	–	–	4,540[r]
Holland	–	–	–	–	–	–	–	2,602
India	77,692	29,463	579	26,163	1,614	–	135,511	189,665
Indonesia	4,684	–	–	–	–	–	4,684	5,403
Ireland	–	–	–	–	–	–	–	2,252
Italy	10,949	–	–	–	–	–	10,949	12,907
Japan	59,206	174,598	36,097	1,833	124,484	–	396,218	368,018
Korea, South	74,037	–	–	–	–	–	74,037	78,576
Malaysia	25,223	8,869	–	143	–	–	34,235	11,950
New Zealand	38,044	–	–	–	–	–	38,044	59,658
Philippines	31,364	3,942	1,090	–	–	–	36,396	40,998
Singapore	12,621	–	–	242	(293)	–	12,570	7,238
Sweden	–	–	–	–	–	–	–	3,503
Switzerland	–	–	–	–	–	–	–	704
Taiwan	16,555	–	–	1,803	39	–	18,397	14,808
Thailand	67	–	–	–	–	–	67	–
Viet Nam, South	–	–	–	–	–	–	–	935
Subtotal	407,963	293,248	135,984	108,160	125,844	884	1,072,083	1,010,322
Undetermined, via Vancouver	–	–	–	–	–	–	–	38,830
Total sales	1,031,847	308,054	1,401,912	902,175	362,462	75,978	4,082,428	3,974,843

Source: Saskatchewan Department of Mineral Resources, Monthly Potash Report.
[1]Common specifications are: standard -28 to +65 mesh, special standard -35 to +200 mesh, coarse -8 to +28 mesh, granular -6 to +20 mesh, each grading a minimum of 60% K_2O equivalent; soluble and chemical grade a minimum of 62% K_2O equivalent.
[r]Revised; – Nil.

in Canada (all in the Province of Saskatchewan) with an installed annual productive capacity of 13.68 million tons of potassium chloride (8.32 million tons K_2O equivalent). All ten mines were in operation throughout 1972, with the exception of Cominco Ltd.'s mine which was reopened in September after a 25-month shutdown that resulted from a flooding of the underground workings; the company spent in excess of $6 million rehabilitating the mine.

Effective June 1, 1972, the Saskatchewan government began collecting a proration fee of 60 cents a ton of potassium chloride.

New Brunswick. An agreement was reached between the Province of New Brunswick and Potash Company of America (PCA) division of Ideal Basic Industries, Inc. granting PCA the right to explore for potash and salt in a 224-square-mile area near Sussex, King's

Table 3. Canada, potash production and trade, years ended June 30, 1963-72

	Production	Imports[1]	Exports
	(short tons K_2O equivalent)		
1963	403,679	75,180	310,633
1964	747,257	58,115	638,749
1965	1,176,408	49,780	983,556
1966	1,927,843	34,522	1,676,174
1967	2,204,231	38,090	2,004,504
1968	2,971,206	32,900	2,723,471
1969	3,085,995	24,600	2,620,672
1970	3,930,662	27,020	3,648,384
1971	3,422,436	29,009	3,319,184
1972	4,151,105	52,052	3,974,278

Source: Statistics Canada, Fertilizer Trade.
[1]Includes potassium chloride, potassium sulphate and sulphate of potash magnesia, except that contained in mixed fertilizers.

County, and providing the company first option to develop a potash mine therein. PCA helped pioneer the potash industries in New Mexico and Saskatchewan and continues to operate mines at both locations. The exploration agreement was concluded in January 1973 and shortly thereafter the company began test drilling; the agreement obligates PCA to complete an approved program within a two-year period.

Potash was discovered in the Sussex area in 1971 by the New Brunswick Department of Natural Resources during the course of a federal-provincial exploration program. The first test hole encountered potash beds as much as 32 feet in thickness and grading 21 to 25.5 per cent K_2O equivalent at depths ranging from 900 to 1,000 feet. A second test, 5 miles distant, intersected 3,000 feet of high-quality salt without potash.

Ontario. In 1971 Shamrock Chemicals Limited began constructing a 240-ton-a-day potassium sulphate plant at Port Stanley, bordering on Lake Erie. Although some trial production runs were made in 1972 and

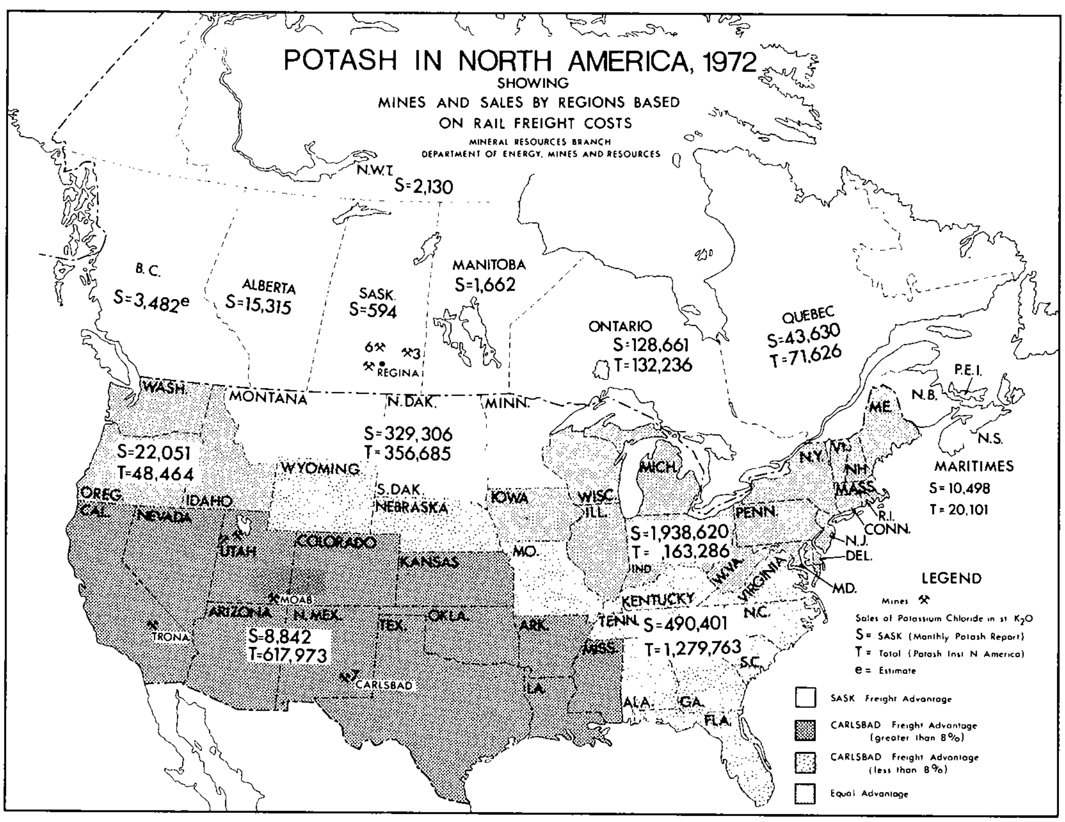


Table 4. Canada, summary of potash mines and production allowables for fertilizer year 1972-73[1]

Company	Initial Production	Production Capacity KCl	Production Capacity K_2O eq.	Production Allowable
		(short tons yearly)		(st K_2O eq.)
International Minerals & Chemical Corporation (Canada) Limited	1962 1967	2,100,000 1,720,000	1,280,000 1,050,000	1,287,801
Kalium Chemicals Limited	1964	1,500,000	937,500	461,090
Potash Company of America	1965	760,000	460,000	226,241
APM Operators Ltd.	1968	1,500,000	912,700	448,892
Alwinsal Potash of Canada Limited	1968	1,000,000	600,000	313,099
Duval Corporation of Canada	1968	1,200,000	732,000	375,876
Cominco Ltd.[2]	1969	1,200,000	720,000	391,117
Central Canada Potash Co. Limited	1969	1,500,000	900,000	442,647
Hudson Bay Mining and Smelting Co., Limited	1970	1,200,000	732,000	369,390
Total		13,680,000	8,324,200	4,316,153

[1]All mines in Saskatchewan; fertilizer year refers to 12 months July 1, 1972 to June 30, 1973. [2]Reopened in 1972 following 1970 flooding of underground workings.

early 1973, the company has experienced considerable start-up difficulties. The manufacturing process involves the reaction of spent sulphuric acid from oil refineries with potassium chloride.

Marketing

About 95 per cent of the world's potash output is for fertilizers, the balance being used for industrial purposes including the manufacture of soaps, glass, ceramics, textiles, dyes, explosives and numerous chemicals.

Canada's potash consumption is about 5 per cent of output, the principal consuming areas being the farm communities of southern Ontario, Quebec and the Maritime Provinces. The United States is Canada's leading market for potash followed by Japan, India, Oceania and, depending upon foreign supply conditions, western Europe.

Potash is a relatively high-bulk, low-value commodity; from a total marketing viewpoint, the producer-seller must consider two costs: mine production (including mining, milling, processing, administration and selling costs) and transportation. The latter frequently exceeds the former and consequently each mining community has a naturally protected market area largely dictated by land transportation costs. But once it enters international seaborne trade, the product can be shipped long distances at little extra cost; in fact, by chartering larger vessels, unit costs can be substantially reduced for shipments to outlets equipped with suitable dock and terminal facilities. Hence, if viewed in global terms, each seller or mining centre has two potential markets, an overland market in which it shares or competes with rival sellers located in the immediate vicinity or in the same continental region and a seaborne market that is accessible to producers situated in various countries.

Within a global framework, Saskatchewan potash enters two markets, the North American and the international seaborne. Total consumption in the two markets is of the same order of magnitude but the former accounts for about three quarters of Saskatchewan's sales. The North American market can be divided on the basis of railway freight rates into four broad regions depicting the degree of market penetration for Saskatchewan potash vis-à-vis New Mexico, which is the other major producing centre on the continent. These regions are illustrated on the accompanying map. The reader should be aware of several anomalies within this simplistic subdivision of the North American market: first, some potash is produced in Utah and it has a freight advantage over both

Table 5. Canada, potash sales by destination, July 1, 1970 to December 31, 1972

Destination	Fertilizer Years		Calendar Years	
	1970/71	1971/72	1971	1972
	(short tons K_2O equivalent)			
Canada				
Alberta	14,798	12,799	18,217	15,315
British Columbia	33,525	11,295	3,809	16,910
Manitoba	1,559	1,487	1,580	1,662
New Brunswick	5,428	5,659	4,717	6,532
Nova Scotia	3,504	857	3,006	2,428
Ontario	116,283	136,577	101,762	128,661
Prince Edward Island	8,109	475	2,586	1,538
Quebec	46,586	41,608	40,711	43,630
Saskatchewan	1,511	700	491	594
Northwest Territories	–	1,574	327	2,130
Total, Canada	231,303	213,031	177,206	219,400
United States				
Alabama	28,957	58,925	22,392	56,788
Arkansas	–	646	187	580
California	–	91	–	91
Colorado	722	927	709	1,349
Connecticut	2,365	2,626	2,541	2,521
Delaware	21,297	34,965	24,328	35,736
Florida	49,522	40,187	49,094	53,924
Georgia	60,043	82,894	59,640	77,468
Hawaii	2,386	4,523	4,524	1,734
Idaho	1,941	4,055	1,514	4,414
Illinois	377,045	477,731	420,526	443,371
Indiana	281,846	327,883	298,212	291,147
Iowa	232,814	336,684	301,883	320,947
Kansas	1,003	1,960	1,400	2,001
Kentucky	39,807	54,119	41,672	59,505
Louisiana	696	1,942	1,635	950
Maine	9,843	17,506	13,663	12,289
Maryland	49,708	63,512	50,480	43,608
Massachussetts	2,358	3,472	3,233	2,567
Michigan	124,806	162,401	142,057	138,015
Minnesota	278,443	327,868	307,837	303,738
Mississippi	7,004	32,272	23,582	16,668
Missouri	23,680	36,384	30,376	41,092
Montana	2,771	5,273	3,031	5,178
Nebraska	16,673	20,209	16,850	20,624
New Hampshire	244	180	303	120
New Jersey	9,559	13,361	11,195	13,542
New Mexico	–	270	–	208
New York	94,058	153,636	124,014	140,518
North Carolina	34,555	72,333	52,413	48,131
North Dakota	10,346	13,235	11,264	11,790
Ohio	254,393	298,552	291,368	239,718
Oklahoma	–	44	44	(512)
Oregon	3,549	4,580	2,606	5,339
Pennsylvania	38,992	49,025	44,873	46,032
Rhode Island	1,188	1,874	1,340	1,736
South Carolina	37,983	80,986	61,464	50,520

Table 5 (concl'd)

Destination	Fertilizer Years		Calendar Years	
	1970/71	1971/72	1971	1972
	(short tons K_2O equivalent)			
United States (cont.)				
South Dakota	9,122	8,282	8,273	8,600
Tennessee	25,090	28,161	27,124	27,026
Texas	61	–	12,711	(12,523)
Utah	362	30	362	30
Vermont	4,592	5,594	4,737	5,447
Virginia	35,516	81,456	65,545	54,529
Washington	7,239	10,333	7,282	12,298
West Virginia	1,965	2,273	1,904	2,626
Wisconsin	172,728	208,083	197,912	198,680
Wyoming	638	470	385	794
Others	6,184	–	–	–
Total, United States	2,364,093	3,131,813	2,748,485	2,790,945
Offshore				
Australia	23,767	53,343	54,254	54,934
Belgium[1]	69	162,541	77,423	135,787
Brazil	14,777	93,408	47,527	88,079
China, People's Republic	–	–	–	18,025
Colombia	–	2,957	2,957	–
England	1,118	24,174	24,404	700
France	–	–	–	13,450
Germany	19	4,540	4,540	–
Holland	–	2,602	2,602	–
India	166,718	190,771	189,665	135,511
Indonesia	357	7,438	5,403	4,684
Ireland	–	2,252	2,252	–
Italy	11,322	23,856	12,907	10,949
Japan	440,857	397,696	368,018	396,218
Korea, South	42,520	106,348	78,576	74,037
Malaysia	8,019	23,450	11,950	34,235
New Zealand	60,887	46,683	59,658	38,044
Philippines	12,566	54,945	40,998	36,396
Singapore	21,493	3,791	7,238	12,570
Sweden	568	3,503	3,503	–
Switzerland	–	704	704	–
Taiwan	8,491	19,371	14,808	18,397
Thailand	–	–	–	67
Viet Nam, South	4,340	935	935	–
Total, offshore	817,888	1,225,308	1,010,322	1,072,083
Undetermined, shipped through Vancouver	15,172	23,658	38,830	–
Grand total	3,428,456	4,593,810	3,974,843	4,082,428

Source: Saskatchewan Department of Mineral Resources, Monthly Potash Report.
[1]Most sales to Belgium were transshipped to other west European markets.
– Nil.

Saskatchewan and New Mexico for that particular region of the U.S. market. Second, Saskatchewan potash can be railed to Vancouver and shipped via the Panama Canal to the eastern seaboard states. And third, New Mexico potash can be railed to Houston and then shipped on intercoastal vessels to the eastern seaboard states or by international seaborne vessels to eastern Canada. In regard to the last-mentioned anomaly, there are two railway freight rates for shipping from Carlsbad to Houston, an export rate of U.S. $7.08 a ton and a coastwise rate of U.S. $9.67 a ton. The implication is that a New Mexico producer can ship potash via rail and water more cheaply to eastern Canada than to New York and, given identical fob mine prices, can compete with transcontinental deliveries from Saskatchewan to eastern Canada. As indicated in Table 1, 62,891 tons and 69,120 tons of potassium chloride were imported from United States in 1971 and 1972, respectively, up sharply from the 1970 level of 23,421 tons.

Table 6. Canada, potash sales by destination showing percentage of total sales for selected areas, 1966-72

	1966	1967	1968	1969	1970	1971	1972
	('000 short tons K_2O equivalent)						
Domestic	130	210	93	292	192.0	177.2	219.4
	6.5	*8.8*	*3.2*	*8.4*	*5.7*	*4.5*	*5.4*
United States	1,246	1,407	1,964	2,270	2,459.2	2,748.5	2,790.9
	62.5	*59.1*	*67.3*	*65.0*	*73.1*	*69.1*	*68.4*
Offshore							
Australia	–	3	8	27	13.7	54.2	54.9
Belgium[1]	–	–	–	–	5.1	77.4	135.8
Brazil	–	5	27	24	–	47.5	88.1
China, People's Republic	–	–	–	–	–	–	18.0
Colombia	–	–	–	–	–	3.0	–
England	. .	. .	. .	. .	26.0	24.4	.7
France	–	–	–	–	–	–	13.5
Germany, West	–	–	–	–	6.7	4.5	–
Holland[1]	130	215	303	233	7.6	2.6	–
India	. .	64	20	18	81.7	189.7	135.5
Indonesia	–	–	–	. .	.9	5.4	4.7
Ireland	. .	. .	. .	. .	9.3	2.3	–
Italy	. .	. .	. .	. .	12.7	12.9	11.0
Japan	340	261	347	366	351.2	368.0	396.0
Korea, South	–	32	29	62	36.5	78.6	74.0
Malaysia	–	–	. .	. .	7.9	12.0	34.2
New Zealand	84	61	51	70	61.8	59.7	38.0
Pakistan	–	–	–	21	15.9	–	–
Philippines	–	8	9	6	12.5	41.0	36.4
Singapore	–	–	15	16	7.2	7.2	12.6
South Africa, Republic	–	14	8	21	1.9	–	–
Sweden	. .	. .	. .	. .	7.5	3.5	–
Switzerland	–	–	–	–	2.7	.7	–
Taiwan	. .	3	19	–	10.2	14.8	18.4
Thailand	–	–	–	–	–	–	.1
Vietnam, South	–	–	–	–	4.3	.9	–
Subtotal	614	766	861	930	683.3	1,010.3	1,072.1
	30.0	*32.1*	*29.5*	*26.6*	*20.3*	*25.4*	*26.2*
Undetermined, via Vancouver	–	–	–	–	29.1	38.8	–
					0.9	*1.0*	
Grand total	1,990	2,383	2,918	3,492	3,363.6	3,974.8	4,082.4

Sources: Saskatchewan Department of Mineral Resources, Monthly Potash Report, 1970-72; U.S. Bureau of Mines, *Minerals Yearbook;* and various other publications.
[1]Most exports to Holland from 1966-69 and Belgium 1971-72 were transshipped to England, Ireland and other west European markets.
. . Quantities unknown but included in subtotal and grand total; – Nil.

Table 7. Canada, consumption of potash fertilizers, years ended June 30, 1963-72

	In Materials	In Mixtures	Total
	(short tons of K_2O equivalent)		
1963	9,704	102,285	111,989
1964	14,087	106,609	120,696
1965	18,264	117,142	135,406
1966	20,644	135,695	156,339
1967	27,806	150,336	178,142
1968	34,771	148,329	183,100
1969	40,967	144,560	185,527
1970	40,475	152,004	192,479
1971	46,831	156,362	203,193
1972	48,340	158,568	206,908

Source: Statistics Canada.

Effective June 1, 1972, the Canadian railways inaugurated seasonal freight rates for potash shipments from Saskatchewan to eastern Canada. For example, the basic rate for deliveries to southern Ontario destinations (in hopper-cars, which carry about 85 per cent of shipments) was set at $22 a ton for the March-May period with reductions ranging from $4.50 a ton for June shipments to $1.50 a ton for February shipments. Nominal reductions of the same magnitude were offered for shipments to Quebec and the Maritimes. Seasonal freight rates (as well as seasonal pricing, which is discussed below) provide an incentive for buyers to take deliveries in the off season thereby spreading shipments to a more regular year-round basis.

The seaborne market can be divided into four broad regions, north Atlantic, south Atlantic, Pacific rim (extending from Japan through Taiwan, Philippines to Oceania) and southeast Asia. When the potash industry was founded in Saskatchewan, a competitive railway freight rate – competitive in the sense that a producer in Saskatchewan would face about the same freight rate as would a producer located in New Mexico – was established for shipments to Vancouver for seaborne export, the rate being $9 a ton of product. In February 1970, the rate was raised to $9.54 a ton and in November 1970 an adjustment was made to reduce the rate to $8.48 a ton for shipper-owned or leased railway cars. Effective June 1, 1972 the rate from Saskatchewan to Vancouver for export was raised to $10.24 a ton on carrier rail cars and $9.18 a ton on shipper-owned or leased cars; in the latter instance, the shipper is also granted a $1-a-ton allowance for car ownership or leasing costs and maintenance.

Table 8. Canada, potash deliveries by product and area, 1971-72

		Agriculture						Industrial
		Potassium Chloride				Potassium Sulphate	Total, Agriculture	
		Standard	Coarse	Granular	Soluble			
		(short tons of K_2O equivalent)						
Atlantic Provinces	1971	2,405	32,712	–	–	639	35,756	–
	1972	–	18,874	1,227	–	1,112	21,213	–
Quebec	1971	8,604	31,116	813	–	2,421	42,954	291
	1972	14,983	55,468	896	–	4,205	75,552	334
Ontario	1971	15,794	97,812	484	41	7,659	121,790	5,438
	1972	11,185	112,563	3,546	142	10,679	138,115	4,804
Prairie Provinces	1971	7,225	2,173	3,294	6,979	126	19,797	1,764
	1972	6,679	1,762	3,208	3,028	145	14,822	5,007
British Columbia	1971	777	4,159	512	188	413	6,049	52
	1972	123	2,102	1,046	90	335	3,696	121
Totals	1971	34,805	167,972	5,103	7,208	11,258	226,346	7,545
	1972	32,970	190,769	9,923	3,260	16,476	253,398	10,266

Source: Potash Institute of North America.
– Nil.

The freight rate for shipments from Carlsbad, New Mexico and from Moab, Utah, to Long Beach, California for export is U.S. $10.40 and U.S. $8.19 a ton, respectively.

Although there are a few exceptions, individual sellers have little or no control over transportation charges so any adjustment in delivered prices must stem from changes in fob mine prices; the ability to adjust mine prices will of course be influenced by production costs and cost-price margins.

In post-World War II years, North American potash producers, who were then concentrated in New Mexico, became accustomed to posting prices, fob mine, such prices being structured according to season and grade and being applicable for the fertilizer year July 1 to June 30. Seasonal price structures were designed to encourage buyers to take deliveries in the off season thereby avoiding transportation bottlenecks during the peak shipping period of February to May; they also provided an incentive for buyers to construct their own storage facilities at their fertilizer plants. Generally speaking, most North American sales whether to Canadian or U.S. customers were 'arms-length' market transactions involving either spot sales or one-year contracts made at posted prices. Offshore sales were handled by the Potash Export Association, a producer organization that was established in 1938 and remained operational until some of its members developed potash mines in Saskatchewan.

When potash mining spread to Saskatchewan, the industry adopted the customary practice of posting prices fob mine for both North American and offshore sales. This time-period also corresponded to the demise of the U.S.-based Potash Export Association resulting in a situation where individual producers whether located in Saskatchewan or New Mexico became responsible for their sales in North America and offshore. This situation more or less prevailed until mid-1972, except for occasional sales made by Canpotex Limited. Canpotex was formed in October 1970 as a marketing and distributing agent for most Saskatchewan producers in bidding for foreign aid and foreign government tenders. Its membership was expanded in mid-1972 to include all Saskatchewan producers and it then became responsible for handling all Canadian offshore sales of potash. Although membership in Canpotex remained voluntary, the Saskatchewan Department of Mineral Resources adopted a policy, effective July 1, 1972, of reducing export allocations to nonmembers.

North American potash prices reached a postwar high during 1965 when the value of Saskatchewan's sales averaged $37.53 a ton K_2O equivalent. In the following year, severe price cutting began to take place to the extent that by 1969 the average value of Saskatchewan sales fell to $19.87 a ton K_2O. Producers continued the practice of issuing price lists but seldom were their price quotations adhered to as rival sellers opted for a policy of 'meeting their competition'. When the Saskatchewan floor price of 33.75¢ Cdn per unit K_2O equivalent became effective in 1970, the producers attempted to restore seasonal pricing as well as the practice of charging premium prices for the more desirable grades (the floor price order did not specify any price structuring). Their efforts were partly successful as unit prices averaged 36.51¢ for the last 9 months of 1970 and 36.72¢ in 1971. Nevertheless, as indicated in the following tables, seasonal and grade price structuring has not been completely restored and price cutting (i.e., from posted prices but subject to the floor price) seems to have been quite widespread in the latter part of 1972. These prices are for muriate of potash, in bulk, carload lots, fob mine Saskatchewan, per unit (20 lb) K_2O in 1972 and the first half of 1973.

Posted prices

Grade and % K_2O min.	Jan.	Feb.- June	July- Aug.	Sept.- Jan./73	Feb.- June/73
	(cents)				
Standard 60-62	35	37	33.75	33.75	35
Coarse 60-62	39	42	37	39	42
Granular 60-62	40	43	38	40	43
Soluble 62	36	38	35	36	37

Realized prices based on Monthly Potash Report

	Jan.	Feb.- June	July- Aug.	Sept.-Dec.
	(cents)			
Standard	34.29	34.30	34.37	33.78
Coarse	35.42	37.93	35.74	34.39
Granular	35.55	39.19	35.44	34.30
Soluble	34.27	36.24	34.42	34.45

World review

Preliminary figures reveal that 19.6 million metric tons K_2O equivalent were produced in 1972, up 3.6 per cent from the previous year's output of 18.9 million metric tons. Growth in world sales, after having recorded a sharp rise from 1970 to 1971, failed to keep pace with output and total producer inventories rose to an all-time high of 3.0 million metric tons. These inventories were, however, concentrated in two countries – Canada and the U.S.S.R. – and their magnitude tended to overshadow a fairly tight supply situation that prevailed in many localized markets at the end of 1972.

In 1972 and for the third consecutive year, the U.S.S.R. ranked as the world's largest potash producer and recorded the largest gain in output and sales. In spite of a remarkable growth pattern in both potash production and consumption during the past decade, the U.S.S.R. has continually failed to meet its targets. Trade reports indicate that much of its difficulties have stemmed from transportation bottlenecks that have hampered distribution of potash fertilizers within the U.S.S.R. as well as the delivery of potash to export terminals, a situation that has led to some curtailment in the production schedules at the potash mines. The first post-World War II exports from the U.S.S.R. were recorded in 1955 and by 1960 had risen to 25 per cent of Soviet output, a proportion that has been more or less maintained throughout the past decade. Since installed productive capacity in the U.S.S.R. far exceeds the 1972 output level and further mine expansions are under way, one can expect continued strong growth in that country's potash production during the remainder of the 1970's.

In East Germany, there have been delays in the start-up of a large mining complex at Zielitz, which is about 85 miles north of Erfurt, the hub of that country's potash industry. Some ore was reportedly hoisted from the new mine in 1972 and hauled to the older refineries for processing; start-up of the new refinery was scheduled for January 1973. Completion of the new complex plus the continued reorganization and re-equipment of the older mines is expected to result in a considerable rise in East German potash output from 1973 to 1975.

West European potash output (Spain, France, West Germany and Italy) reached an all-time high of 5.0 million metric tons in 1971 but then declined slightly in 1972, largely as a result of a labour dispute that kept France's potash mines closed from October to

Table 9. World potash production, sales and inventories, 1970-72

	1970		1971		1972^p	
	Production	Sales	Production	Sales	Production	Sales
	('000 metric tons K_2O equivalent)					
U.S.S.R.	4,087	3,950	4,600^e	4,450^e	5,000	4,800
Canada	3,173	3,051	3,573	3,606	3,928	3,703
United States	2,476	2,421	2,347	2,351	2,450	2,460
Germany, East	2,419	2,415	2,450^e	2,460^e	2,500	2,520
Germany, West	2,306	2,300	2,443	2,450^e	2,440	2,440
France	1,768	1,785	1,870	1,857	1,600	1,625
Spain	521	520	555^e	555^e	530	530
Israel	546	582	568	570^e	580	580
Italy	139	139	150	150^e	180	180
Congo	125	122	262	262	280	270
Others^e	100	100	100	100	100	100
Total	17,660	17,385	18,918	18,811	19,588	19,208

Year-end producer inventories

	1970	1971	1972
U.S.S.R.^{e}	950	1,000	1,100
Canada	870	683	1,040
United States	412	388	370
Germany, East^e	250	225	200
Germany, West^e	100	80	80
France	95	96	80
Israel	61	60	60
Others^e	80	80	80
Total	2,818	2,612	3,010

Sources: Saskatchewan Department of Mineral Resources, U.S. Bureau of Mines and the *Journal of World Phosphorus and Potassium.*
^{p}Preliminary; ^{e}Estimated.

mid-December. The work stoppage, combined with a repeated failure of the Spanish mines and the Congolese producer (whose potash is marketed by the French industry) to reach their output targets, contributed to a rather tight supply situation in markets traditionally served by the west Europeans. On the basis of Spain's 1967 National Plan for Economic and Social Development, that country's potash output was expected to reach 1.0 million metric tons by 1972, but as indicated in Table 9, scarcely more than one half that level has been achieved. In the Congo, mining problems have hampered ore recovery and there are indications that output is not likely to greatly exceed that which was achieved in 1972.

In the United States, potash output in 1972 increased almost 5 per cent from the previous year. Although New Mexico output was up slightly, most of the increase resulted from a reopening in March 1972 of Texas Gulf Inc.'s Moab, Utah, mine. Production at Moab had commenced in 1965 using conventional underground mining methods but technical difficulties arising from minute faults and lower-than-anticipated prices prevented profitable operation; conventional mining was suspended in mid-1970 and the company began converting to solution mining methods. Unlike Kalium Chemicals Limited's mine in Saskatchewan where weak brines are injected into undisturbed beds through a series of cased wells, Texas Gulf injects water into the old mine workings (reported to be 403 miles of tunnels) for dissolution of the salts; the brine is pumped into a series of 23 surface ponds for open air, solar evaporation (annual rainfall in the area is about 8 inches). The crystallized salts and slurry, 40 per cent KCl and 60 per cent NaCl, are 'harvested' by earth-mover-like cutting machines and transferred to the flotation cells and evaporator circuits of the original plant for separation. Capital expenditures for the conversion is estimated at U.S. $8 million.

The company had reported net unamortized cost in the mine and facilities, less related deferred taxes, at U.S. $41 million on December 31, 1969, and has subsequently provided for a special charge of U.S. $4.7 million to offset equipment loss from the initital investment; net unamortized cost at December 1, 1971 was U.S. $43 million.

Elsewhere, there are projects under way to expand the world's potash supply base. Construction on Britain's first potash mine near Staithes, Yorkshire, is nearing completion in preparation for start-up towards the end of 1973. The twin-shaft, $60-million mine will be operated by Cleveland Potash Ltd., a joint venture financed by Charter Consolidated Ltd. and Imperial Chemical Industries Ltd. The Yorkshire deposits occur at a depth of 3,200 to 4,000 feet and grade 26 to 30 per cent K_2O equivalent. The new mine is not expected to emerge as an important market force in world potash trade during the 1973/74 fertilizer year, but thereafter one can anticipate that its output will gradually displace virtually all British imports of potassium chloride. The mine has been designed to produce 1.0 million tons of potassium chloride annually, a quantity that approximates the current consumption level of muriate in Britain and Ireland. In Australia, Texada Mines Pty. Ltd. in 1972 awarded a contract with an engineering firm to construct a A.$4.5 potash recovery plant at Lake McLeod, Western Australia. Lake McLeod is a natural brine lake and the potash plant will complement a salt-recovery operation completed in 1970. In Brazil, feasibility studies are under way to develop salt-potash-magnesium deposits situated near the coast in the states of Sergipe and Alagoas. Preliminary plans call for a $70-million expenditure to develop a 500,000-ton-a-year potassium chloride mine by 1975; Brazil imports all its muriate needs, which currently stand at about 500,000 tons annually.

Outlook

The outlook for Saskatchewan potash producers is mixed. Some officials claim that the outlook is favourable, their arguments going something like this: the world population is continually growing and increased food requirements will generate greater usage of fertilizers and hence of potash; as potash consumption rises much of the annual increase in demand will accrue to Saskatchewan producers. Moreover, demand for potash is claimed to be inelastic with respect to price, the reason being that a farmer's cash outlay for potash accounts for such a small part of his total annual expenditures. Hence, a decrease in price will not lead to a rise in quantity demanded, the outcome being that producer revenues fall directly in proportion to price decreases. Empirical evidence supports this hypothesis for North America and other advanced economies but there is some doubt about its validity in southeast Asia, which is viewed as one of the key potential growth areas for potash and other fertilizers. Negotiators for the People's Republic of China reportedly stated at the August 1972 potash trade talks with Canpotex representatives that the volume of sales would be a reflection of prices.

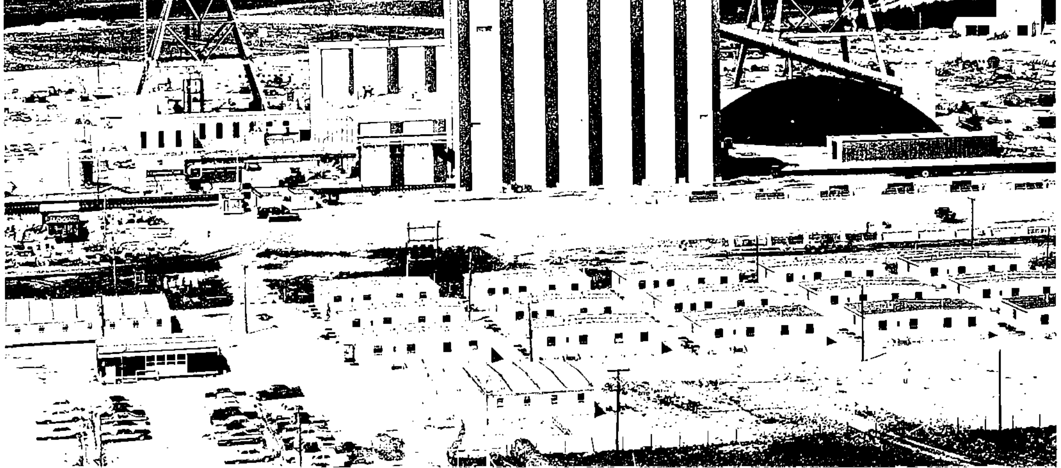
A rise in quantity demanded, stemming from price decreases, is likely to remain small relative to total world consumption but the assumption of inelastic demand also tends to overlook the supply side of the market. Normally, we expect that a rise in prices, or 'stable' prices substantially above production cost, will lead to an increase in supply. For many minerals such as potash, short-run price fluctuations are unlikely to stimulate significant changes in supply but in the long run the opposite must be expected. Although world potash capacity has expanded since 1969, it would be unfair to attribute such expansion to stronger world prices arising from the Saskatchewan control programs; generally speaking, three to five years are required to construct new mines, so any new capacity brought on stream from 1970 to 1973 would simply reflect earlier investment decisions. The same cannot be said for expansions or mines brought on stream after 1973. One North American producer has predicted that for the balance of the 1970's, potash production capacity will remain constant in Saskatchewan, the United States, France and West Germany, while 10.8 million metric tons of K_2O equivalent capacity will be brought on stream in other countries, the U.S.S.R. accounting for almost half of the increase. Presumably this estimate was based on the assumption that prices would remain at recent levels.

Should that prediction prove correct and that amount of new potash enter world markets, it does not augur well for Saskatchewan's medium-term outlook. In fact, the gradual introduction of 10.8 million metric tons of additional output (i.e., above the 1972 level of an estimated 19.6 million metric tons K_2O) will be almost sufficient to meet the predicted increase in world demand in 1980, the implication being that the Saskatchewan industry would continue to operate well below its potential. Admittedly, historical evidence for the U.S.S.R. potash industry indicates that their output targets have been overly optimistic, but the foregoing estimates suggest that, if the objective of the Saskatchewan industry is to achieve full capacity utilization in the foreseeable future, it should avoid complacency with respect to its pricing and output policies. It would be presumptuous to expect that annual increments in demand will automatically accrue to Saskatchewan producers.

The United States will continue to be the largest single market for Saskatchewan potash by virtue of its geographical location and its dominance as a consumer. Nevertheless, the prospect of building a strong, viable industry in Saskatchewan also hinges on an expansion of offshore sales. Canada's first offshore potash shipments of commercial importance were made in 1963. By 1969 Saskatchewan potash had captured 22 per cent of world markets served by seaborne shipments only to have that share fall to 16 per cent in 1970. Although some recovery was made in 1971-72 and the recent sale of potash to the People's Republic of China lends support to the prospect of expanding our sales in southeast Asia, the industry must continue its efforts to expand offshore sales.

For the short term, the outlook for Saskatchewan potash is favourable even at current price levels. Supplies were tight in western Europe at the close of 1972 and are likely to remain so until 1974. This situation, combined with strong demand and rising prices for world agricultural products plus currency revaluation in many of Canada's trading partners, is likely to result in a fairly sharp rise in Saskatchewan potash sales in 1973 and early 1974.

Hudson Bay Mining and Smelting Co., Limited's potash mine near Rocanville, Saskatchewan. (George Hunter photo).



Rare Earths

C. J. CAJKA

The rare earth elements, sometimes called the lanthanons, are a group of 15 chemically similar metals having atomic numbers 57 to 71 in Group III of the periodic table of elements. Scandium and yttrium are similar to the rare earth elements in many respects and are usually classed with them.

These elements are neither rare nor earths. By comparison, cerium is more abundant than tin or cobalt and almost three times as abundant as lead. Thulium, the least common of the rare earths, is more abundant than silver, gold, and platinum combined. The metals were originally classified "rare" because they are seldom concentrated in nature like most other elements and their widespread occurrence in the earth's crust was recognized only in recent times. The term "earth" is derived from earlier terminology when insoluble oxides, the common compounds of rare earths, were simply referred to as earths.

Lanthanon-bearing minerals contain all members of the rare earth elements but either the light (cerium) group or the heavy (yttrium) group predominates in each mineral. The rare earth metals are typically associated with alkalide complexes and pegmatites and secondary concentration can occur in placer, beach sand, phosphatic and other sedimentary deposits. Commercial production has been derived from carbonatite occurrences, placer and beach sand deposits, uranium ores and phosphatic rocks. The relative abundance of the various rare earths in the ores presently being mined has no relationship to the market demand for the individual products. As a result, some rare earth products are readily available at low cost, while others, particularly high-purity metal and compounds, are considerably more expensive. Research continues to explore the properties of the rare earth metals to identify potential new markets but, for some, no significant use has yet been found. Development has proceeded, first, to find markets for those compounds that are available and second, to find and develop sources of supply to meet changing industrial requirements.

Table 1. Rare earth elements

Atomic No.	Name	Abbreviation	Abundance in Igneous Rocks (ppm)
	Light rare earths		
21	Scandium	Sc	5.0
57	Lanthanum	La	18.3
58	Cerium	Ce	46.0
59	Praseodymium	Pr	5.5
60	Neodymium	Nd	23.8
61	Promethium	Pm	(not measurable)
62	Samarium	Sm	6.5
63	Europium	Eu	1.1
64	Gadolinium	Gd	6.3
	Heavy rare earths		
39	Yttrium	Y	28.0
65	Terbium	Tb	0.9
66	Dysprosium	Dy	4.5
67	Holmium	Ho	1.1
68	Erbium	Er	2.5
69	Thulium	Tm	0.2
70	Ytterbium	Yb	2.6
71	Lutetium	Lu	0.7
		Total	153.0

Noteworthy advances in new markets have occurred at two to three year intervals for the past decade. Beginning with the traditional cigarette lighter flints and carbon-arc markets, new uses have grown in the glass polishing compound, petroleum catalyst, television tube phosphor, nodular iron and high-strength low-alloy steel industries. When colour TV was initially introduced, the forecast for europium and yttrium consumption in phosphors was very optimistic and this optimism led to overproduction by 1967. Part of the problem was a slower than anticipated growth in the TV market. A second factor was the overestimate of the quantity of rare earth metals used in each television set. Canadian production has undergone drastic adjustments; yttrium concentrate suppliers have reduced shipments each successive year until 1971 when deliveries stopped.

New markets for specific members of the rare earth group have resulted in increased production of all rare earth metals because of their natural association in ores. Similarly, production costs for some rare earth members, byproducts of the refining process, have diminished. Availability and declining costs have been important factors in the development of new uses. There is growing optimism, now that several markets are well established, that the rare earth metals industry will expand at a steady rate.

Canadian industry

From 1966 to 1970, the world's major source of yttrium concentrate was the uranium mines in the Elliot Lake district of Ontario. All rare earths, except promethium, have been detected in these ores. The Elliot Lake ores contain about 0.11 per cent uranium oxide (U_3O_8), 0.28 per cent thorium oxide (ThO_2) and 0.057 per cent rare earth oxides (REO).

There are no facilities in Canada for the separation of the individual rare earths from each other. Denison Mines Limited, the only Canadian producer of rare earth concentrate in recent years, ceased production of this byproduct in mid-1970 when it experienced difficulty in marketing the product. Denison shipped some concentrate in 1971 but the quantity and value was not reported. During 1966 and 1967, Rio Algom Mines Limited recovered thorium and rare earth concentrate at its Nordic mill, but did not resume production when the milling of uranium ores was transferred to the Quirke mill.

Successive declining shipments since 1967 reflect the oversupply of yttrium concentrate in world markets. However, there are indications that these markets are improving and Denison Mines Limited plans to reactivate the yttrium circuit at its Elliot Lake plant in 1973. The company has negotiated a contract with Molybdenum Corporation of America for yttrium oxide sales until March 1976.

Rare earth elements, associated with apatite, are present in the Nemegos No. 6 magnetite deposit, which is located in the Chapleau area of Ontario. Multi-Minerals Limited plans to stockpile non-magnetic tailings, when this property attains production, at an annual rate of about 30,000 tons for future recovery of phosphate and the rare earth metals. These tailings are expected to contain 4.1 per cent rare earth oxide equivalents. The company has reported reserves of 100 million pounds of REO in the No. 6 orebody.

Besides the large reserves in Elliot Lake uranium ores, rare earths are also associated with uranium deposits at Agnew Lake, which is 40 miles east of Elliot Lake and where the REO content is about twice that of Elliot Lake ores, in the Bancroft area of Ontario, and at one deposit in British Columbia. Phosphorite formations in western Canada contain small quantities of rare earths as do Florida phosphates imported into Canada for the production of phosphoric acid. Other potential sources include apatite – rich carbonatites.

Shipments of rare earth concentrate since 1966 are summarized in the following table:

Table 2. Canadian shipments of rare earth concentrates

	Y_2O_3 in Concentrate	Value
	(pounds)	($)
1972	–	–
1971	...	...
1970	73,000	657,000
1969	85,443	671,500
1968	113,330	936,067
1967	172,551	1,594,298
1966	20,724	130,223

. . .Not reported; – Nil.

World industry

The minerals monazite and bastnaesite are the main sources of the cerium group of rare earths. These are processed to recover mixed rare earths for low-value products such as mischmetal or further processed at much higher cost to separate individual rare earths.

Monazite recovery is a byproduct of mining beach sands for rutile, zircon and ilmenite. Australia, India, Brazil, Malaysia, and the United States are the principal producers. In the United States, there is some recovery from beach sands in Georgia and Florida and from molybdenum mining in Colorado.

The Molybdenum Corporation of America (Molycorp) mine, at Mountain Pass, California, is the main source of concentrates for cerium group rare earths and, unlike monazite, concentrates from this unusual deposit in carbonatite do not contain thorium. The ore, mined in a small, low-cost, open pit, grades 8 to 10 per cent rare earth oxides. The rare earth distribution in per cent is cerium 50, lanthanum 33, neodymium 12, praseodymium 4, samarium 0.5, gadolinium 0.2, europium 0.1, and yttrium group 0.2. The adjacent mill produces a flotation concentrate grading 60 per cent rare earth oxide, a leached concentrate grading 70 per cent and a calcine grading 90 per cent. A chemical and solvent extraction plant makes intermediate rare earth products and separates a number of rare earths including europium. Further processing is carried out at Louviers, Colorado and York, Pennsylvania.

Molycorp is increasing the capacity of its Mountain Pass mine in 1973 by 50 per cent to approximately 60 million pounds REO. Production in 1973 is scheduled for 48 million pounds of REO, a 100 per cent increase over the 1972 rate.

Aluminum Company of America (Alcoa) and Molycorp have formed a joint company, Rare Earth Metal Company of America (REMCOA), to build a pilot plant at Washington, Pa. This plant will employ a new electrolytic process, which is expected to lower production costs, to produce mischmetal and pure rare earth metals. A full-scale plant, with an annual capacity of about 500,000 pounds, is being considered.

Indian Rare Earths Limited (IRE) has increased annual capacity at the Alwaye processing plant, India, to 4,500 tons of monazite. The Alwaye plant produces rare earth in the chloride, fluoride, oxide and hydrate form. IRE plans to increase mineral sands production at Manavalakurichi and Chevara to double current output and the company is considering a new mining operation in the Gapalpur area of Orissa.

The Finnish company Kemira Oy (formerly Typpi Oy) recovers rare earths by solvent extraction as a byproduct of phosphate fertilizer production from apatite. The source of apatite is the apatite-nepheline mines in the Kola Peninsula of the U.S.S.R. Many companies produce fertilizer from apatite but do not recover the rare earth content. Other sources of phosphate rock, such as those from Florida, contain lesser amounts of the rare earth metals and have different compositions.

The mineral xenotime, valuable for its yttrium content, is recovered from heavy mineral rejects of the Malaysian tin industry and from retreatment of monazite concentrate, itself a byproduct, from Western Australia. A pilot plant to produce yttrium oxide from xenotime concentrate, derived from a feldspar operation in southern Norway, has been built by A/S Metal Extractor Group of Norway (Megon). Xenotime concentrates are usually treated in Europe or Japan.

Some uranium ores contain the rare earth elements and are an important source for the yttrium group. Solution liquors, following uranium and thorium extraction, are treated to precipitate the rare earth elements. Canadian production is of this type. Potential sources in Australia are Mary Kathleen Uranium Limited and Field Metals and Chemicals Pty. Limited. The rare earth minerals euxenite, samarskite and fergusonite are occasionally available but they are difficult to treat and markets for the contained yttrium group are limited.

Promethium isotopes have half-lives ranging from seconds to 18 years and, therefore, are extremely rare in nature. The commercial source of promethium 147 is from waste fission products in atomic reactors. Its radioactive properties are attractive as a power source in space research as well as in luminescent paints.

Table 3. Principal world processors of rare earth ores and concentrates.

Austria
- Treibacher Chemische Werke Aktiengesellschaft

Brazil
- Commissao National de Energia Nuclear, Industrias Quimicas Reunidas

Britain
- British Flint and Cerium Manufacturers Limited
- British Rare Earths Limited
- London and Scandinavian Metallurgical Company
- Rare Earth Products Limited (a Thorium Ltd. and Johnson Matthey Chemicals Limited joint venture)

Finland
- Kemira Oy

France
- Etablissements Tricot
- Produits Chimiques Pechiney St. Gobain

West Germany
- Otavi Minen and Eisbahn Ges.
- Th. Goldschmidt A.G.

India
- Indian Rare Earths Limited

Japan
- Ogino Chemical Company
- Nippon Yttrium Company
- Santoku Metal Industry Company
- Shin-Etsu Chemical Industry Company
- Wako Bussan Company

United States
- American Potash and Chemical Corporation, Lindsay Rare Earth Division*
- Michigan Chemical Corporation
- Molybdenum Corporation of America
- Nucor Comp., Research Chemicals Division
- Reaction Metals Inc., a subsidiary of Rare Earth Industries, Inc.
- Ronson Metals Corporation, Cerium Metals and Alloys Division

Table 3 (cont'd)

W.R. Grace and Company, Davison Chemical Division
Gallard-Schlesinger Chemical Manufacturing Corp., Atomergic Chemetals Co. Division
Transelco, Inc.

U.S.S.R.
State controlled. Output is sold through Techsnabexport

* The company's processing facilities, located in West Chicago, are scheduled for closure in late 1973.

Uses

Most rare earth metal consumption is in the form of chlorides, oxides and mischmetal. Small quantities of fluorides, oxalites, chlorates, nitrates, carbonates and silicides are used in a number of applications. High purity metal forms are used sparingly, mostly in research work. Traditionally, the rare earth metals, alloys and compounds have been expressed in terms of rare earth oxide (REO) equivalents.

Metallurgical applications, amounting to over 40 per cent of the market, displaced petroleum catalysts as the number one use for rare earth metals in 1972. Mischmetal is a suitable nodulizing alloy that promotes ductility in cast iron by neutralizing the harmful effects of trace elements which inhibit the formation of nodular graphite. The ductile iron industry has realized significant cost savings through the substitution of mischmetal for more expensive additives. Mischmetal and rare earth silicides are being used increasingly in high strength – low alloy (HSLA) steels to counter the deleterious effects of sulphur. The conventional method of treating undesirable sulphur is to combine it with magnesium but magnesium sulphide elongates when rolled and the resulting steel is weaker in the transverse direction. The addition of mischmetal results in a HSLA steel that is nearly equally strong in the transverse and longitudinal directions. HSLA steels are becoming important in gas and oil pipelines, automobiles, trucks, trains, ships, and construction equipment. Mischmetal, which is mostly cerium, lanthanum, neodymium and praseodymium, has a stable market in lighter flints. However, the lighter flint market is becoming a less important outlet as mischmetal applications grow in the iron and steel metallurgical fields.

The second largest use of the rare earth group is for catalysts in the cracking operation of petroleum refining. Although naturally mixed elements were originally used in catalysts, the trend has been to chloride mixtures of lanthanum, neodymium and praseodymium. Relative consumption in this field has been declining in recent years but it still accounts for nearly 35 per cent. Palladium is a substitute for the rare earth elements in petroleum refining catalysts.

The third most important market for rare earth metals, in terms of volume, is the glass polishing industry. Commercial grade cerium and mixed rare earth oxides are used extensively in optical, mirror and plate glass polishing. Plate glass polishing has been reduced since the introduction of the Pilkington float glass process but there is no substitute for rare earth oxide compounds in high quality optical polishing.

The glass industry employs rare earth additives for their many unique characteristics. Cerium oxide, in small quantities, is an effective glass decolourizer. Due to their ability to absorb ultraviolet light, cerium and neodymium oxides are used in transparent bottles to inhibit food spoilage and in welders' goggles, sunglasses and optical filters. For glass colouring, praseodymium imparts a yellow-green colour, neodymium a lilac, europium an orange-red, and erbium a pink. Lanthanum is a major component of optical glass and cerium glass is used for windows in atomic reactors.

Rare earth oxides and fluorides are used in significant quantities in carbon-arc lamps where a high intensity white light is desirable.

A high-value application is in the electronics field where rare earth oxides are used as phosphors in colour television tubes, temperature compensating capacitors and associated circuit components. Although the volume of europium and yttrium oxides used in colour television phosphors is small, the value is disproportionately large because of the high degree of purity required in this application. Minor quantities of the rare earth group are used in laser materials, atomic fire extinguishers, nuclear reactor absorption and shielding materials, magnesium and aluminum alloys, brazing alloys, low-corrosion alloys, gemstones, self-cleaning oven catalysts, ceramic and porcelain stains and microwave controls.

An important new market is rare earth-cobalt permanent magnets. Samarium-cobalt permanent magnets are now in use that have twice the strength of any conventional permanent magnet. These magnets are usually fabricated by powder metallurgy methods, which facilitate the procedure for inducing a high magnetic flux in the metal. High strength permanent magnets are used in special applications such as aerospace equipment, where the greater cost can be justified in terms of better performance. For the future, it seems likely that high strength permanent magnets will be an important component in electric generating plants and new transportation systems.

Rare earth metals catalysts have been identified as possible inexpensive alternatives to platinoid catalysts in automobile exhaust converters. The rare earth-based converters have shown promise in reducing carbon monoxide and nitrogen oxide emissions but more research is necessary. Initially, the automotive industry has opted for platinum-based systems to meet emission control standards set for U.S. vehicles in 1975.

Prices

Prices of rare earth products have not changed from those quoted earlier in 1972. The wide spread in prices between different products is a function of the degree of processing, purity and demand. Some typical prices as given in *American Metal Market* for December 15, 1972, are as follows, per pound: mischmetal $3.10; 99.9 per cent cerium oxide $6; cerium metal $21; 99.9 per cent yttrium oxide $32; yttrium metal $150; 99.9 per cent lanthanum oxide $4.15; lanthanum metal $35; 99.9 per cent samarium oxide $38; samarium metal $125; 99.9 per cent thulium oxide $1,350; thulium metal $2,750; 99.9 per cent lutetium oxide $2,300; lutetium metal $6,500.

Rhenium

J.J. HOGAN

Rhenium occurs principally in low grade porphyry copper ores containing molybdenum and is recovered as a byproduct of the treatment of molybdenum concentrates. The rhenium content in porphyry copper ore is only a few parts per million (p.p.m.) whereas the molybdenite concentrates produced from these ores have a rhenium content varying from 300-2,000 p.p.m. Rhenium has been identified in some molybdenum, manganese and uranium ores but in concentrations too low to be of economic significance under present technology and price structure.

Canadian rhenium production comes from the copper-molybdenum ore of Utah Mines Ltd. (Island Copper mine) at Port Hardy, Vancouver Island, British Columbia. The ore occurs mainly in altered volcanics, and in this respect differs from the porphyry copper deposits which have been the major source of rhenium in the United States and Chile. No information is available on the rhenium content of the byproduct molybdenite concentrates produced from the porphyry copper ores in the southern interior of British Columbia, although the metal has been identified in the deposit of Lornex Mining Corporation Ltd., near Kamloops.

The United States, the largest producer of rhenium metal and salts in the non-communist world, recovers rhenium from porphyry copper ores in the western states. The metal is produced by Cleveland Refractory Metals (CRM) of Solon, Ohio, a division of Chase Brass & Copper Co. Incorporated (a subsidiary of Kennecott Copper Corporation) and S.W. Shattuck Chemical Co., Denver, Colorado, a division of Engelhard Minerals & Chemicals Corporation. Chile recovers rhenium from its large porphyry copper ore deposits. Other producing countries are Sweden, Russia, Belgium and Luxembourg, France and West Germany; the last three countries recovering the metal from imported molybdenite concentrates, mainly from Chile and Zaire.

Production

Rhenium is a recent addition to the metals produced in Canada with production being first recorded in 1972. Island Copper mine reported the contained rhenium metal in the molybdenite concentrates produced in 1972 varied between 1,200-1,800 p.p.m. Shipments of molybdenite concentrates to a refinery in the United States and in western Europe totalled about 400 tons and contained approximately 1,200 pounds of rhenium. Terms of the sales agreements for the contained rhenium varied from an outright sale to an arrangement whereby the rhenium was recovered on a toll basis and the product returned to the company for subsequent sale to purchasers.

Statistical data on the world output of rhenium and on the value are not available. Production in the United States in 1972, by far the largest producer, was estimated by the U.S. Bureau of Mines at 5,600 pounds. Chile is believed to be the next largest producer.

Rhenium is recovered from flue gases emitted from the roasting of byproduct molybdenite concentrates. Under properly controlled temperature conditions rhenium volatilizes as rhenium heptoxide (Re_2O_7) which is readily soluble in an aqueous solution. Flue dust particles which carry about 10 per cent of the rhenium contained in the roaster feed are recycled to the roaster. Before flue gas technology was developed flue dust was the major source of the metal. To extract the rhenium, flue gases are cleaned of dust particles and wet scrubbed to dissolve the rhenium oxide. The rhenium-bearing solution is conditioned for ion exchange treatment by the addition of certain chemicals to remove impurities. It is clarified and the rhenium is adsorbed on an ion exchange resin. Further hydrometallurgical steps are carried out until a high-purity ammonium perrhenate (NH_4ReO_4) is produced which is converted to metal powder by hydrogen reduction. The metal powder is pressed and sintered into bars which are cold-rolled to form different shapes. Perrhenic acid ($HReO_4$) is obtained by the reaction of rhenium heptoxide with water.

Properties and Uses

Rhenium, a relatively new metal that was first isolated in 1925, has become an important industrial metal because of special or unique properties. The metal is highly refractory, having a melting point of 3,100°C, second to that of tungsten, and maintains strength and ductility at high temperatures even after heating above the crystallization temperature. Its density is 21, exceeded only by that of the platinum metals group. Pure rhenium can be cold-worked but requires high temperature recrystallization annealing to ensure maximum ductility. It is difficult to work at normal hot-working temperatures because it tends to become brittle. The metal can be welded by tungsten arc-inert gas techniques, the welds being ductile. It has good corrosion resistance to halogen acids. Rhenium alloyed with tungsten or molybdenum improves the ductility and tensile strength of these metals. At room temperature rhenium has a high resistivity, a property which finds application in the rapid initial heating of filaments and heating elements. Stable oxide film on rhenium does not appreciably increase electrical resistance because the oxides are conductive and this property, plus good resistance to wear and arc corrosion, makes the metal ideally suited for electrical contacts.

The United States consumes most of the world's output of rhenium, a major application being in the development of the rhenium-platinum bi-metallic catalyst used in reforming units to produce a high octane gasoline of low lead content.

Rhenium powder is used to produce ductile, high temperature tungsten and molybdenum based alloys which are used in the electronic field. Other applications of rhenium are high temperature thermocouples, temperature controls, electronic devices, flashbulb filaments and heat shields.

Outlook

The development of rhenium as an industrial metal has taken place recently and has not shown any clearly defined growth pattern. The potential short term supply is limited to that available from byproduct molybdenite concentrates from low grade porphyry copper ores.

Until the use of rhenium was developed as a replacement for part of the platinum used as a catalyst in petroleum refining, supply was more than adequate to meet demand. Rhenium consumption in catalytic applications began on a small scale in 1969 and by 1972 had increased to the point that it was largely responsible for demand being about equal to production. It is expected that in the short term supply and demand will be in balance.

Prices

According to *Metals Week* the United States price for rhenium to Aug. 13, 1972, was $1,325 a pound for rhenium contained in perrhenic acid and $1,400 for rhenium metal powder. On Aug. 14, S.W. Shattuck Chemical Co. quoted prices of $875 a pound for rhenium contained in perrhenic acid and $975 for the metal powder. Cleveland Refractory Metals held its quote at the higher price.

Tariffs

Canada – not specifically enumerated in Canadian tariffs

United States Item No.		On and After January 1		
		1970	1971	1972
		%	%	%
628.90	Rhenium unwrought, and waste and scrap	7	6	5(1)
628.95	Rhenium wrought	12.5	10.5	9

(1) Duty on waste and scrap temporarily suspended as provided by P.L. 91-298, effective to June 30, 1973

Source: Tariff Schedules of the United States Annotated 1972 T.C. Publication 452.

Salt

W.E. KOEPKE

Salt production in Canada in 1972 was virtually unchanged from the previous year. Domestic demand for salt to manufacture industrial chemicals was especially strong while demand for salt to control snow and ice on highways and city streets remained unchanged. Export demand was off considerably and imports were up quite sharply. Virtually all Canada's salt trade is with the United States.

Canada's salt industry in 1972 can be summarized as follows: three rock salt mines were operated at virtually full capacity; six evaporator plants and one fine salt plant that uses byproduct salt from a potash solution-mine were in operation; significant quantities of byproduct salt from potash mining were further processed for use to control snow and ice on roads; and four establishments were brining salt for the direct manufacture of industrial chemicals. Salt was discovered in the Magdalen Islands, Province of Quebec.

Production and developments in Canada

Canadian salt production falls into three statistical classes: mined rock salt, fine vacuum salt, and salt content of brines used or shipped plus salt recovered in chemical operations. In Table 3 plants described as brining for vacuum pan evaporation are classified as producers of fine vacuum salt; the other two classes are self-explanatory. Total salt production (shipments) in Canada in 1972 was 5,535,000 tons valued at $43.1 million; the tonnage was down slightly but its value was considerably higher than in 1971. Production of mined rock salt accounted for three quarters of Canada's total salt output and amounted to 4,150,000 tons in 1972, down marginally from 1971. Output of fine vacuum salt and salt in brines remained unchanged.

Deposits and occurrences

Salt occurs in solution in seawater, in some spring and lake waters, in many subsurface waters, and in solid form in surface and underground deposits. Although seawaters contain the largest reserve of salt and contribute substantial quantities of solar evaporated salt to the world's annual salt output, underground bedded and dome deposits supply the largest part of mankind's salt requirements.

In Canada, underground salt deposits have been found in all provinces except British Columbia. They have also been found in the District of Mackenzie, Northwest Territories, and there is geological evidence that suggests the presence of underground salt deposits in some of the Arctic islands. Bedded rock salt deposits in southwestern Ontario, Saskatchewan and Alberta, and dome deposits in Nova Scotia are the sources of most of Canada's salt output. In past years, salt has been recovered from brine springs and natural subsurface brines in Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan and Alberta. Salt springs are also common to certain parts of British Columbia.

Ontario. Thick salt beds underlie much of southwestern Ontario extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Upper Silurian Salina Formation and at depths from 900 to 2,700 feet, can be identified and traced from drilling records. Maximum bed thickness is 300 feet with aggregate thickness reaching as much as 700 feet. The beds are relatively flatlying and undisturbed thereby permitting easy exploitation.

In 1972 these beds were being exploited through two rock salt mines, one at Goderich and one at Ojibway, and through brining operations at Goderich, Sarnia and Windsor. Domtar Chemicals Limited neared completion of a $5.8 million expansion program which will boost the productive capacity of its Goderich salt mine to 2.25 million tons of salt annually.

Atlantic region. Salt deposits occur in isolated subbasins of a large sedimentary basin that underlies the northern mainland of Nova Scotia and extends westward under the bordering areas of New Brunswick, northeastward under Cape Breton Island and under Prince Edward Island, the Magdalen Islands and southwestern Newfoundland. The salt beds occur within the Mississippian Windsor Group and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies or domes and brecciated structures of rock salt.

In New Brunswick, the Department of Natural Resources headed a joint federal-provincial exploration program in which two test holes were drilled in King's County in 1971; one encountered 1,600 feet of salt and the other 2,900 feet, with the tops of the salt

Table 1. Canada, salt production and trade, 1971-72

	1971		1972[p]	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
By type				
Mined rock salt	4,045,894	23,012,000	4,041,000[e]	..
Fine vacuum salt	625,552	14,227,000	625,000[e]	..
Salt content of brines used or shipped and salt recovered in chemical operations	870,458	2,872,000	869,000[e]	..
Total	5,541,904	40,111,000	5,535,000	43,110,000
By province				
Ontario	4,171,454	24,121,302	4,150,000	27,850,000
Nova Scotia	889,256	9,484,389	800,000	8,625,000
Saskatchewan	209,071	4,097,337	250,000	3,920,000
Alberta	245,111	2,292,352	304,000	2,580,000
Manitoba	27,009	115,328	31,000	135,000
Total	5,541,901	40,110,708	5,535,000	43,110,000
Imports				
Total salt and brine				
United States	496,182	3,063,000	615,934	4,125,000
Mexico	341,347	504,000	293,480	424,000
Romania	55,995	175,000	55,765	242,000
Bahamas	2,128	14,000	22,428	142,000
Italy	9,512	72,000	25,160	113,000
West Germany	294	15,000	4,213	53,000
Britain	2	1,000	4,658	49,000
Norway	349	7,000	1,158	31,000
Spain	15,135	74,000	–	–
Other countries	1,069	6,000	1,114	13,000
Total	922,013	3,931,000	1,023,910	5,192,000
Exports				
United States	..	6,940,000	..	4,909,000
Sweden	..	–	..	24,000
Britain	..	9,000	..	12,000
Bermuda	..	10,000	..	9,000
Leeward and Windward Islands	..	5,000	..	7,000
Nigeria	..	38,000	..	–
Other countries	..	27,000	..	26,000
Total	..	7,029,000	..	4,987,000

Source: Statistics Canada.
[p]Preliminary; .. Not available; – Nil; [e]Estimated by Statistics Section, Mineral Resources Branch.

being at 800 and 600 feet, respectively. One test hole also penetrated significant thicknesses of potash, for which an exploration permit was issued early in 1973. Further exploration of the salt beds is also expected.

In August 1972, it was announced that Quebec Mining Exploration Company (SOQUEM) had discovered a major salt deposit in the Magdalen Islands, 50 miles north of Prince Edward Island. The discovery test encountered salt at a depth of 450 feet and drilling was terminated at 2,000 feet, still in salt.

The rock salt deposits in Prince Edward Island occur at a depth of over 14,000 feet, and in southeastern Newfoundland, salt has been found in the St. Fintan's area at a depth of about 1,000 feet.

Table 2. Canada, salt production and trade, 1963-72

	Production[1]				Imports	Exports
	Mined Rock	Fine Vacuum	In Brine and Recovered in Chemical Operations	Total		
			(short tons)			($)
1963	1,771,242	486,940	1,132,537	3,390,719	332,581	3,701,356
1964	1,874,225	537,553	1,225,365	3,637,143	405,574	3,618,569
1965	2,399,919	558,346	1,289,796	4,248,061	441,601	4,996,509
1966	2,180,671	571,497	1,376,654	4,128,822	509,548	3,588,000
1967	3,023,397	554,337	1,417,894	4,995,628	567,012	5,926,000
1968	3,230,305	553,280	1,080,739	4,864,324	644,153	5,921,000
1969	3,007,256	557,028	1,093,481	4,657,765	695,638	5,107,000
1970	3,607,336	609,252	1,142,308	5,358,896	618,021	7,430,000
1971	4,045,894	625,552	870,458	5,541,904	922,013	7,029,000
1972^p	4,041,000^e	625,000^e	869,000^e	5,535,000	1,023,910	4,987,000

Source: Statistics Canada.
[1] Producers' shipments.
^{p}Preliminary; ^{e}Estimated by Statistics Section, Mineral Resources Branch.

Exploitation of salt deposits in the Atlantic provinces in 1972 was confined to one rock salt mine and an associated evaporator plant at Pugwash, Nova Scotia, and a brining operation at Amherst, Nova Scotia. During the last few years, Domtar Chemicals Limited has been exploring salt deposits in Cape Breton Island and the company has apparently acquired a concession in anticipation of developing a commercial operation.

Prairie Provinces. Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba, northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian, Elk Point Group, with thinner beds occurring in Upper Devonian rocks. Depths range from 600 feet at Fort McMurray, Alberta, to 3,000 feet in eastern Alberta, central Saskatchewan and southwestern Manitoba, and to 6,000 feet around Edmonton, Alberta, and across to southern Saskatchewan. Cumulative thicknesses reach a maximum of 1,300 feet in east-central Alberta. The beds lie relatively flat and undisturbed. The same rock sequence contains a number of potash beds that are being exploited in Saskatchewan.

These rock salt deposits were being exploited at four locations in the Prairie Provinces in 1972 – Saskatoon and Unity, Saskatchewan, and Lindbergh and Fort Saskatchewan, Alberta. In addition, naturally occurring subsurface salt brines in Manitoba were being used for caustic soda and chlorine manufacture at Brandon. Fine salt was also produced from by-product brines from a potash solution mine at Belle Plaine, Saskatchewan. Elsewhere in Saskatchewan, waste salt from potash mining has occasionally been used; in 1972, International Minerals & Chemical Corporation (Canada) Limited, at Esterhazy, supplied a significant quantity of salt to Kleysen's Cartage Co. Ltd. for drying at a nearby plant and sale for snow and ice control on roads.

Recovery method

Canadian producers employ three different methods for the recovery of salt from depth for the production of dry salt and for direct use in the chlor-alkali industry. The method employed depends upon the deposit and the type of salt required by the consumer. Conventional mining methods are used to mine rock salt deposits that are relatively shallow and are located in areas convenient to large markets that do not require a high-purity product.

Brining methods are used to recover salt from subsurface deposits as well, usually from greater depths. The brine can be evaporated to produce high-purity fine vacuum salt or can be used directly in the manufacture of chemicals. Salt is similarly recovered from natural subsurface brines.

A third method of recovering salt is as a coproduct of potash mining, a practice quite common in Europe. In Canada, this technique is being used on a commer-

Table 3. Canada, summary of salt producing and brining operations, 1972

Company	Location	Initial Production	Remarks
Nova Scotia			
The Canadian Rock Salt Company Limited	Pugwash	1959	Rock salt mining at a depth of 630 feet
	Pugwash	1962	Dissolving rock salt fines for vacuum pan evaporation
Domtar Chemicals Limited	Amherst	1947	Brining for vacuum pan evaporation
Ontario			
Allied Chemical Canada, Ltd.	Amherstburg	1919	Brining to produce soda ash
The Canadian Rock Salt Company Limited	Ojibway	1955	Rock salt mining at a depth of 980 feet
The Canadian Salt Company Limited	Windsor	1892	Brining, vacuum pan evaporation and fusion
Dome Petroleum Limited	Sarnia	1969	Brining to develop storage cavity
Dow Chemical of Canada, Limited	Sarnia	1950	Brining to produce caustic soda and chlorine
Domtar Chemicals Limited	Goderich	1959	Rock salt mining at a depth of 1,760 feet
	Goderich	1880	Brining for vacuum pan evaporation
Prairie Provinces			
Dryden Chemicals Limited	Brandon, Man.	1968	Pumping natural brines to produce caustic soda and chlorine
Northern Industrial Chemicals Ltd.*	Saskatoon, Sask.	1968	Brining to produce caustic soda and chlorine
Domtar Chemicals Limited	Unity, Sask.	1949	Brining, vacuum pan evaporation and fusion
The Canadian Salt Company Limited	Lindbergh, Alta.	1948	Brining, vacuum pan evaporation and fusion
Dow Chemical of Canada, Limited	Fort Saskatchewan, Alta.	1968	Brining to produce caustic soda and chlorine
The Canadian Salt Company Limited	Belle Plaine, Sask.	1969	Producing fine salt from byproduct brine from potash mine

*Managed by Canadian Industries Limited.

cial scale at only one potash mine, of the solution type, which lends itself to the recovery of a good-quality salt brine. The other potash producers generally regard the waste salt as unmarketable, although some shipments have been made for snow and ice control.

A fourth method is by solar evaporation of sea or salty lake waters, a process commonly used in warm, arid climates.

Rock salt mining. Access to rock salt deposits for conventional mining is through vertical shafts, normally 16 feet in diameter, serving the mining zone at depths of 630 to 1,760 feet. Mining is normally by the room-and-pillar method, the dimensions depending on the depth and thickness of the salt deposit. Rooms vary from 30 to 60 feet in width and from 18 to 50 feet in height and pillars vary from about 60 to 200 feet square. Extraction rates range from 40 to 60 per

Table 4. World salt production, 1970-72

	1970	1971[p]	1972[e]
	('000 short tons)		
United States	45,928	41,106	43,897
People's Republic of China	17,600	16,500	..
U.S.S.R.	14,300	14,300	..
West Germany	11,515	9,274	10,000
Britain	10,128	10,191	10,200
France	6,044	7,216	7,000
India	6,160	6,382	6,400
Canada	5,359	5,542	5,535
Italy	4,815	4,900	5,000
Other countries	38,567	42,096	70,300
Total	160,416	157,507	158,332

Sources: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1971, and U.S. Bureau of Mines Commodity Data Summaries, January 1973: for Canada, Statistics Canada.
[p]Preliminary; [e]Estimate; .. Not available; estimates included under "Other countries".

cent. The mining operation consists of undercutting, drilling, blasting, loading and primary crushing. Underground haulage is by shuttle cars, trucks and conveyor belts. Milling involves crushing, screening and sizing; at one mine the milling is done underground. The products, ranging from about one half inch to a fine powder, normally have a purity of 96 per cent or better. Most of the gypsum, anhydrite and limestone impurities are removed by crushing and screening; removal of the remainder from small amounts of the coarser salt fractions is achieved with electronic sorters.

Most of the mined rock salt in Canada is shipped in bulk by water, rail and truck, much of it being used for snow and ice control.

Brining and vacuum pan evaporation. Brining is essentially a system of injecting water into a salt deposit to dissolve the salt and then pumping a saturated salt solution to the surface. Water injection and brine recovery can be accomplished in a single borehole with casing and tubing or in a series of two or more cased wells. A brine field normally has from 2 to 20 wells depending on the quantity of brine needed for the surface operation. Depths of the brine fields in Canada range from 1,100 feet to 6,500 feet. Saturated salt brine contains 26 per cent NaCl, which amounts to about 3 pounds of salt per gallon of fluid. At the surface, the brine is either evaporated to produce fine vacuum salt or used directly in the manufacture of chemicals.

Canadian producers use a vacuum pan process to evaporate the brine and produce fine salt. The brine is purified to remove gypsum and other impurities and then fed into a series of three or four large cylindrical steel vessels under vacuum for a triple- or quadruple-effect evaporation. The salt crystallizes and is removed as a slurry; it is then washed, filtered and dried. Product purity is generally 99.5 per cent or better.

Final processing involves screening, the introduction of additives, compression into blocks, briquettes and tablets, or compaction, recrushing and packaging to prepare as many as 100 different salt products. In some cases, small quantities are melted at a temperature of about 1,500°F and allowed to cool producing a fused salt, which is particularly suitable for use in water softeners.

Canadian consumption and trade

Salt is marketed in at least 100 different forms, packages and containers and its direct and indirect uses number in the thousands. The largest single market for salt in Canada is for snow and ice control on highways and city streets. By comparison with other uses, this market is new, having expanded in Canada from less than 100,000 tons in 1954 to an estimated 2.3 million tons in 1972.

The next largest consumer of salt is the industrial chemical industry, particularly the manufacture of caustic soda (sodium hydroxide) and chlorine. Salt for four caustic soda and chlorine plants is obtained from on-site brining or natural brines; others use mined rock salt or imported solar salt. Other industrial chemicals that require significant quantities of salt in the manufacturing process include sodium carbonate (soda ash), sodium chlorate, sodium bicarbonate, sodium chlorite and sodium hypochlorite.

The pattern of Canada's salt trade has changed considerably in the past few years. Because of its low unit value and availability in most key market areas, salt is seldom hauled long distances, except in the case of seaborne and intercoastal shipments where greater mileage entails little additional cost.

In the five years prior to 1968, Canada exported about 1.4 million tons of salt annually to the United States; about half was in the form of salt brine to feed a soda ash plant in Detroit, the balance consisted largely of mined rock salt. Brine sales ceased in 1968 and exports to the United States declined significantly but regained sharply in 1970-71, only to drop off again in 1972. Nearly all of Canada's salt exports to the United States are in the form of mined rock salt. Salt exports to other countries normally involve small quantities of fine salt.

Salt imports into Canada climbed steadily from 192,000 tons in 1960 to 696,000 tons in 1969, fell slightly in 1970 and then rebounded to 1,023,910 tons in 1972. From 1963 to 1969, our imports consisted mainly of: fishery salt for the Atlantic provinces from Spain (about 40,000 tons yearly); solar salt for use in fisheries and west coast industrial

Table 5. Canada, available data on salt consumption, 1969-72

	1969	1970	1971[e]	1972[e]
		(short tons)		
Industrial chemicals	1,735,117	1,619,936	1,700,000	1,800,000
Snow and ice control[e]	1,800,000	2,000,000	2,300,000	2,300,000
Slaughtering and meat packing	46,609	45,706	46,000	50,000
Food processing				
Fish products	20,559	13,670	16,000	20,000
Bakeries	14,928	14,056	15,000	15,000
Miscellaneous food preparations	17,541	18,019	18,500	19,000
Fruit and vegetable preparations	20,554	19,301	20,000	21,000
Other food processing	3,070	. .	3,000	3,000
Breweries	649	780	800	800
Dairy factories and process cheese	11,912	11,794	12,000	12,000
Leather tanneries	7,957	7,554	8,000	8,500
Soaps and cleaning preparations	2,812	3,149	3,200	3,500
Dyeing and finishing textiles	1,502	597	1,000	1,000
Artificial ice	728	824	850	850
Pulp and paper mills	58,725	61,302	62,000	65,000
Grain mills[1]	51,134	50,555	52,000	55,000
Fishing industry[e]	80,000	90,000	90,000	95,000

Source: Statistics Canada.
[1]Includes feed and farm stock salt in block and loose forms.
[e]Estimated; . . Not available.

chemical plants from Caribbean countries and Mexico (rising from 118,000 to 356,000 tons); and rock salt from the United States (rising from 166,000 to 291,000 tons). Imports from Spain ceased by 1972, while those from the United States increased sharply from 292,000 tons in 1970 to 616,000 tons in 1972; United States producers bordering on the lower Great Lakes are able to take advantage of low shipping rates to capture spot sales in southern Ontario and Quebec, particularly for snow and ice control salt in large metropolitan areas. Imports from Mexico decreased slightly in 1972 and substantial quantities were acquired from Romania and Italy.

Outlook

The outlook for Canada's salt industry is generally favourable. Although there is an abundant supply of salt on world markets and imports into Canada have been rising quite sharply, domestic producers are in a strong competitive position and will continue to serve the bulk of this country's needs. The industry must, however, remain vigilant and make every effort to reduce costs, or else imports will continue to make greater inroads into the Canadian market, particularly in those areas served by water transport. The average value of mined rock salt shipments in Canada in 1971 was $5.70 a ton fob mine; the unit value of imports from Romania and Mexico in 1971 averaged $3.12 and $1.48 a ton (the Mexican salt contains 4 to 5 per cent moisture). In the fall of 1972, Romanian salt was offered for sale delivered to the Toronto area for $10.85 a ton.

In spite of a favourable outlook, Canadian producers cannot expect the growth rates in demand enjoyed in the 1960's. Demand for salt to control snow and ice on highways and city streets soared during the 1960's and was especially strong in the 1970/71 and 1971/72 winters. The milder climatic conditions experienced in the 1972/73 winter has left some salt in storage and there could be a slight weakening in this market during late 1973. Salt usage on our roads has been the subject of criticism from some environmentalists concerned about the effects of salt-laden runoff waters.

Demand for salt to manufacture industrial chemicals is expected to remain strong. In January 1973, Canadian Industries Limited announced plans to build a $30-million chlor-alkali plant at Bécancour, Quebec; the announcement did not indicate the supply source for salt. Shortly afterwards, The Canadian Salt Company announced a $2-million expansion program, including the construction of a new headframe and outfitting a second deeper shaft for production, at its Pugwash mine in Nova Scotia; completion is scheduled for mid-1974.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(¢ per 100 lb)		
92501-1	Common salt (including rock salt)			
	On and after Jan. 1, 1971	free	1/2	5
	On and after Jan. 1, 1972	free	free	5
92501-2	Salt for use of the sea or gulf fisheries	free	free	free
92501-3	Table salt made by the admixture of other ingredients when containing not less than 90 per cent of pure salt	(%)	(%)	(%)
	On and after Jan. 1, 1971	5	6	15
	On and after Jan. 1, 1972	5	5	15
92501-4	Salt liquors and seawater	free	free	free

United States

Item No.		On and After January 1 1971	1972
420.92	Salt in brine	6%	5%
		(¢ per 100 lb)	
420.94	Salt in bulk	1	0.8
420.96	Salt, other	0.5	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa, Canada. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Sand and Gravel

D. H. STONEHOUSE

Sand is defined as granular mineral material resulting from the natural disintegration and abrasion of rock or the processing of completely friable sandstone, passing a 3/8-inch sieve, almost all passing a No. 4 (0.187-inch) sieve and almost all remaining on a No. 200 (0.003-inch) sieve. Gravel is defined as granular material resulting from similar processes and predominantly retained on a No. 4 sieve, the cutoff between commercial sand and gravel. Material finer than 200-mesh is called silt or clay depending on the particle size.

Commercial sand and gravel deposits are generally classified into one of four categories according to origin or method of deposition. Those that are composed of sand and gravel that has been carried by rivers and streams are referred to as fluvial deposits. They exhibit limited size gradation and the distribution of size ranges and shapes can vary greatly, depending on whether the streams had been meandering, fast-flowing, narrow or shallow. Glacial deposits were distributed from massive ice sheets over large areas of Canada and the United States as well as other countries. They consist of rock particles of various types, shapes and sizes and display little sorting or gradation. Marine and lake deposits are usually of hard, tough material, well segregated and well worn to rounded shapes. Unstratified mixtures of sand and gravel, covering the complete size range and occurring on top of the parent rock, are termed residual deposits. These are not usually of commercial importance because of the large amount of softer clays associated with the mass.

The quantities of sand and gravel produced in Canada bear close relation to the amount of construction being performed, particularly heavy or engineering construction. The peak production achieved during 1966 and attributed to the pre Expo '67 surge in construction has not since been reached, although by 1972 normal yearly increments in the amount of aggregates required by the construction industry have resulted in a total apparent consumption of about 216 million tons of sand and gravel. As a supplier of raw materials to a volatile and cyclical industry, the sand and gravel industry must in turn be capable of rapid adjustment between go and no go situations.

The Canadian Industry

Sand and gravel deposits are widespread throughout Canada and large producers have established "permanent" plants as close to major consuming centres as possible. Urban expansion has greatly increased demand for sand and gravel in support of major construction. Paradoxically, urban spread has not only tended to overrun operating pits and quarries but has extended at times over areas containing mineral deposits, precluding use of these resources. Further complications have arisen in recent years as society has become increasingly aware of environmental problems and of the need for planned land utilization. Municipal and regional zoning must determine and regulate the optimum utilization of land. Industry must locate to minimize the environmental effects of plant operations. Also, provision must be made for rehabilitation of pit and quarry sites in order to ensure the best sequential land use. The frequency with which small quarries and pits materialize to supply short-lived, local demands, leaving unsightly properties, has prompted action by municipal and provincial governments to control or to prohibit such activity.

Ideally, the exploitation of sand, gravel and stone deposits should be done as part of the total land use planning package, such that excavations are designed to conform with a master plan of development. Ontario seems to be leading other provinces in enacting legislation to control pit and quarry licensing, operation and rehabilitation and its new laws are typical of what can be expected in other provinces. Ontario regulations apply to operations in designated areas and to rehabilitation of depleted sites. To date 68 townships have been designated. They are located along the Niagara Escarpment, in the Toronto-centred region and in the Ottawa, Kingston and London areas.

In addition to large aggregate operations usually associated with some other phase of the construction industry such as a ready-mix plant or an asphalt plant, there are many smaller, privately owned producers serving small, localized markets. These are often operated on a seasonal or part-time basis. Many larger operations are short-term, intermittently serving as a supply arm of a heavy construction company and providing material for a given project. Provincial departments of highways operate regional or divisional quarries to supply roadbed material for new and repair work.

Sand and gravel must be quarried, screened, washed, stockpiled and transported in large volume to compensate for the relatively low unit value received. Transportation and handling often double the plant cost, making it necessary to utilize close-in reserves and influencing the scope of exploration for new deposits. The need for an inventory of aggregate materials surrounding regions of large population growth cannot be too strongly emphasized.

Materials competitive with sand and gravel include crushed stone and the lightweight aggregates, depending on the application considered. It has been estimated that total aggregate consumption in some Canadian urban centres could reach 18 tons per capita by 1980 – in 1967 the Toronto-Hamilton area consumed about 15.4 tons per person. This could make outlying deposits not only attractive but necessary and could also encourage development of underwater deposits. It is not completely impossible that areas of concentrated population, such as the eastern seaboard of the United States, where reserves of aggregates are already becoming depleted, will have to import their requirements perhaps by boat or barge. Large tonnages of crushed limestone are exported annually from Canada's west coast quarries, particularly from Texada and Aristazabal islands, for cement, lime and aggregate use in Oregon and Washington.

The main uses for sand and gravel are: as fill, granular base course and finish course material for highway construction; coarse and fine aggregates in concrete manufacture; coarse aggregate in asphalt production and fine aggregate in mortar and concrete blocks. Specifications vary greatly depending on the intended use and many tests are required to determine the acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analyses, affects the uniformity and workability of a concrete mix as well as the strength of the concrete, the density and strength of an asphalt mix and the durability, strength and stability of the compacted mass when aggregates are used as fill or base course material. Of importance also are tests to determine the presence of organic impurities or other deleterious material, the resistance of the aggregate to abrasion and to freeze-thaw cycles, the effects of thermal expansion, absorption, porosity, reactivity with associated materials and surface texture.

The use of sand and gravel as backfill in mines continues along with increasing use of cement and mill tailings for this purpose. Abrasive sands, glass sand, foundry sands and filter sands are also produced.

Table 1. Canada, construction spending by provinces, 1971-73

	1971[1]	1972[2]	1973[3]
	(millions of dollars)		
Newfoundland	552	480	415
Prince Edward Island	61	63	73
Nova Scotia	452	461	543
New Brunswick	352	374	417
Quebec	3,412	3,633	3,905
Ontario	5,597	6,233	6,460
Manitoba	671	744	840
Saskatchewan	534	578	620
Alberta	1,845	1,967	2,172
British Columbia	2,226	2,262	2,320
Yukon and Northwest Territories	160	233	292
Canada	15,862	17,028	18,057

Source: Statistics Canada.
[1] Final. [2] Preliminary. [3] Forecast.

Table 2. Canada production (shipments) sand and gravel by provinces, 1970-72

	1970		1971		1972^p	
	000 st	$000	000 st	$000	000 st	$000
Newfoundland	4,335	4,474	5,564	5,827	4,400	5,700
Prince Edward Island	827	640	1,554	978	1,500	800
Nova Scotia	7,187	6,623	6,004	6,345	6,000	6,300
New Brunswick	6,883	1,969	4,985	2,593	5,000	2,700
Quebec	36,795	17,503	41,605	20,087	42,000	20,200
Ontario	82,877	54,419	77,631	57,104	80,000	60,000
Manitoba	14,930	9,406	16,695	12,199	16,700	12,200
Saskatchewan	8,963	4,279	11,321	6,503	10,000	6,000
Alberta	16,042	13,000	18,679	16,285	18,500	16,000
British Columbia	23,817	21,245	29,253	24,707	31,500	26,000
Canada	202,656	133,558	213,291	152,628	215,600	155,900

Source: Statistics Canada. ^{p} Preliminary.

Table 3. Canada, production (shipments) sand and gravel, by uses, 1970-71

	1970 000 st	1971* 000 st
Roads – construction, maintenance, ice control	132,070	141,748
Concrete aggregate	20,773	30,441
Asphalt aggregate	6,964	9,969
Railroad ballast	3,091	4,699
Mortar sands	1,698	1,710
Backfill for mines	1,445	2,909
Other fill	17,084	21,441
Other uses	19,531	374
Total sand and gravel	202,656	213,291
$000	133,558	152,628

Source: Statistics Canada.
*Breakdown, by Statistics Section, Mineral Resources Branch, from Statistics Canada data.

Table 4. Production (shipments) sand and gravel, by uses, by areas, 1970-71

		Atlantic Provinces	Quebec	Ontario	Western Provinces	Canada
		(000 st)				
Roads	1970	15,445	30,324	51,346	34,955	132,070
	1971*	14,182	34,675	42,597	50,294	141,748
Concrete aggregate	1970	1,246	2,847	10,068	6,612	20,773
	1971*	1,039	3,541	15,618	10,243	30,441
Asphalt aggregate	1970	1,224	994	2,241	2,505	6,964
	1971*	1,689	1,298	4,053	2,929	9,969
Railroad ballast	1970	505	285	300	2,001	3,091
	1971*	283	561	124	3,731	4,699
Mortar sand	1970	38	141	1,225	294	1,698
	1971*	46	189	1,107	368	1,710
Backfill for mines	1970	171	1	1,249	24	1,445
	1971*	108	40	2,758	3	2,909
Other fill	1970	93	1,561	7,375	8,055	17,084
	1971*	626	1,202	11,263	8,350	21,441
Other uses	1970	510	642	9,073	9,306	19,531
	1971*	134	99	111	30	374
Total sand and gravel	1970	19,232	36,795	82,877	63,752	202,656
	1971*	18,107	41,605	77,631	75,948	213,291

Source: Statistics Canada.
* 1971 Breakdown, by Statistics Section, Mineral Resources Branch, from Statistics Canada data.

Table 5. Canada, exports and imports of sand and gravel, 1970-72

	1970		1971		1972^p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Exports						
Sand and gravel						
United States	1,239,692	1,936,120	774,639	1,089,000	697,138	997,000
West Germany	440	1,609	22	1,000	22	1,000
Jamaica	4	281	7	...	14	1,000
Other countries	56	1,640	58	4,000	–	–
Total	1,240,192	1,939,650	774,726	1,094,000	697,174	999,000
Imports						
Sand and gravel, not elsewhere stated						
United States	502,425	537,000	675,272	785,000	1,067,532	1,032,000
West Germany	–	–	–	–	101	17,000
Others	314	1,000	3	...	–	–
Total	502,739	538,000	675,275	785,000	1,067,633	1,049,000

Source: Statistics Canada. – Nil. ... less than $1,000.

Table 6. Canada, sand and gravel, production (shipments) and trade, 1962-72

	Production	Imports	Exports
	st	st	st
1962	181,245,762	838,894	354,107
1963	189,570,503	561,965	356,124
1964	193,791,358	593,455	461,464
1965	205,260,264	570,977	687,941
1966	217,271,189	566,800	700,255
1967	215,212,700	757,603	601,419
1968	205,234,509	683,490	496,525
1969	201,581,498	859,898	457,918
1970	202,656,000	502,739	1,240,192
1971	213,291,000	675,275	774,726
1972^p	215,600,000	1,067,633	697,174

Source: Statistics Canada.

Even the common products such as sand and gravel require a sales and distribution effort which depends upon forecast data supplied by monitoring relevant indicators. One such indicator is the number of regional housing starts which in turn can be projected to determine future needs for roads, driveways, shopping centres, schools, etc. Heavy construction awards can be used to provide an estimate of the quantity of aggregate required for given projects, over given periods of time.

Movement of sand and gravel from the pit or quarry is normally by truck, and as quarry sites are being forced to locate farther from the consuming areas, costs in excess of 5 cents a ton-mile added to basic loading charges can become so large in total that alternative sources are continually being sought. It is only rarely that a unit-train concept would be applicable because of the wide physical distribution of consumers within an area and because optimum utilization of such facilities would be difficult to attain. Bulk "hook and haul" trains are used in the Toronto area to haul minimum loads of 4,000 tons at negotiated freight rates.

On average, total aggregate consumption will rise in line with population increases, housing requirements and construction in general. Sand and gravel consumption will continue in competition with crushed stone and, in some applications, with lightweight aggregates. New resource reserves must be located, assessed and made part of any community development planning or regional zoning, with optimum land and resource utilization in mind. In the search for new sources of sand and gravel some countries are turning to the sea bed. The use of huge pumps and specially equipped ships to draw gravel from the sea floor and deposit it in attendant barges is already common practise in Britain. Such methods of obtaining aggregates can have far reaching environmental effects.

Prices for graded, washed and crushed gravel and sand will show slow but steady increase based on greater property costs, more sophisticated operating techniques and equipment, pollution and environmental consideration and higher labour costs.

Selenium and Tellurium

J.J. HOGAN

SELENIUM

World production of selenium is derived as a byproduct of copper refining. Minor amounts are recovered from lead smelting. Selenium-bearing minerals occur sparsely disseminated throughout the earth's crust but not in sufficient concentration to allow commercial exploitation for their selenium content alone.

The output of selenium as metal or compounds comes from the copper refining nations, including the United States, Canada, Japan, Belgium-Luxembourg, Sweden, Mexico, Zambia, Peru, Finland and Australia. The first three nations listed are the major producers. There is also production in the U.S.S.R. and other communist countries. Selenium supply is dependent upon copper production and, because of this, it varies with copper output and not with the pressures of demand. A minor amount of selenium is recovered from secondary sources. Preliminary world production figures for 1972 show an increase over the previous year. With the exception of Canada, all countries reporting had an increased production.

Production of selenium in all forms from Canadian ores in 1972 was 655,000 pounds valued at $5,836,000 compared with 718,440 pounds in 1971 valued at $6,530,619. Lower copper production from the copper mines in Ontario and Quebec, the major source of selenium, was responsible for the decline. Refined production from all sources, including imported material and secondary sources was 720,392 pounds, down from 885,931 pounds in 1971.

Domestic consumption in 1972 amounted to 20,700 pounds, up from 15,700 pounds in 1971. An increased consumption of selenium in the glass industry was largely responsible for the improvement. Canada exports most of its production, the United States being the major market followed by Britain. In 1972, Canada supplied about 80 per cent of the selenium imported into the United States.

Canadian Copper Refiners Limited at Montreal East, Quebec, operates Canada's largest selenium recovery plant. The company's refinery treats anode copper from the Noranda smelter of Noranda Mines Limited, the Murdochville smelter of Gaspe Copper Mines, Limited, both in Quebec, and blister copper from the smelter of Hudson Bay Mining and Smelting Co., Limited at Flin Flon, Manitoba. The selenium plant can produce commercial-grade metal (99.5 per cent Se), high-purity metal (99.9 per cent Se) and a great variety of metallic and selenium compounds. Annual capacity is 450,000 pounds of selenium in metal and salts.

The 270,000 pound-a-year selenium recovery plant of The International Nickel Company of Canada, Limited at Copper Cliff, Ontario, treats tankhouse slimes from the company's Copper Cliff copper refinery and its Port Colborne, Ontario, nickel refinery. The marketable product is minus 200 mesh selenium powder (99.5 per cent).

Consumption and Uses

Selenium is used in the glass, electrical-electronic, xerographic, chemical, rubber, steel and pharmaceutical industries. Development of the dry-plate rectifier during World War II brought about a sharp increase in the demand for selenium that persisted into the postwar period. Price increases led to substitutions in all applications and subsequently the demand and price for selenium declined. Stable supply and research on the element fostered by the Selenium and Tellurium Development Association Inc. gradually developed new markets and recaptured some of the lost markets.

The glass making industry is one of the major consumers of selenium. Small quantities added to the glass batch neutralize the greenish tinge imparted to glass by iron impurities in the sand. Selenium is meeting with some competition from cerium in this application. The brilliant ruby-red glass used in traffic and other signal lenses, automotive taillights, marine equipment, infrared equipment and decorative tableware is produced by adding larger quantities of selenium to the glass batch. An increasing amount of selenium is used in tinted "black" glass which is used as the outer facing of many highrise office buildings.

An important use of selenium in the electrical field is in the manufacturing of rectifiers. They are used in electroplating, welding, battery charging and in other similar applications. Selenium is used in specialty transformers, varying in size from a fraction of a watt to 500 kw. Xerography, a dry reproduction process, uses a large quantity of selenium. The photoelectric cells which find application in light-sensitive instruments are a small consumer of selenium.

Selenium has wide application in the chemical industry, the most important being the manufacture

Table 1. Canada, selenium production, exports and consumption, 1971-72

	1971		1972p	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Quebec	550,127	5,000,654	387,000	3,444,000
Manitoba	32,534	295,734	124,000	1,106,000
Ontario	128,000	1,163,520	109,000	974,000
Saskatchewan	7,779	70,711	35,000	312,000
Total	718,440	6,530,619	655,000	5,836,000
Refined[2]	885,931	. .	720,392	. .
Exports (metal)				
United States	334,600	3,511,000	344,400	3,578,000
Britain	225,600	2,225,000	134,500	1,216,000
Brazil	–	–	9,000	80,000
Argentina	700	6,000	5,700	51,000
India	3,100	8,000	6,700	36,000
Italy	–	–	1,100	10,000
Jamaica	–	–	1,000	9,000
Other countries	7,500	69,000	2,400	22,000
Total	571,500	5,819,000	504,800	5,002,000
Consumption[3] (selenium content)	15,686	. .	20,677	. .

Source: Statistics Canada.
[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary materials. [2]Refinery output from all sources, including imported material and secondary sources. [3]Available data, consumption of selenium products (metal, metal powder, oxide), selenium content, as reported by consumers.
pPreliminary; . . Not available; – Nil.

Table 2. Canada, selenium production, exports and consumption, 1963-1972

	Production		Exports, Metals[3]	Consumption[4]
	All Forms[1]	Refined[2]		
		(pounds)		
1963	468,772	462,385	445,700	12,424
1964	465,746	462,795	401,300	13,968
1965	512,077	514,595	451,200	15,888
1966	575,482	546,085	588,100	20,533
1967	724,573	754,360	539,400	21,017
1968	635,510	620,033	787,100	21,440
1969	599,415	820,277	872,300	15,572
1970	663,336	854,452	686,100	15,730
1971	718,440	885,931	571,500	15,686
1972p	655,000	720,392	504,800	20,677

Source: Statistics Canada.
[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary material. [2]Refinery output from all sources, including imported material and secondary sources. [3]Exports of selenium metal, metal powder, shot, etc. [4]Consumption (selenium content), as reported by consumers.
pPreliminary.

of the orange-red-maroon cadmium sulphoselenide pigments. They have considerable light stability, maintain their brilliance and are resistant to heat and chemical action. Their most important application is in the expanding high-temperature-cured plastic industry, but are also used to colour ceramics, paints, enamels and inks.

In proportions from 0.2 to 0.35 per cent, selenium imparts improved machinability to stainless steel without affecting its corrosion resistance properties, and in lesser amounts improves the forging characteristics of steel. Small quantities of iron selenide, from 0.01 to 0.05 per cent are widely used as an additive in steel casting to prevent pinhole porosity.

Finely ground metallic selenium and selenium diethyldithiocarbamate (selenac) are used in natural and synthetic rubber to increase the rate of vulcanization and to improve the aging and mechanical properties of sulphurless and low-sulphur rubber. Selenac is used as an accelerator in butyl rubber.

Selenium is used in the organic chemical and pharmaceutical industries and in the manufacture of cortisone and nicotine acids. Selenium and selenium compounds are used in the preparation of various proprietary medicines for the control of dermatitis in

Table 3. Noncommunist world production of selenium, 1970-72

	1970	1971	1972[e]
		(pounds)	
United States	1,005,000	657,000	745,000
Canada	663,000	718,000	655,000
Japan	449,000	524,000	660,000
Sweden	170,000	110,000	140,000
Zambia	. .	. .	. .
Belgium and Luxembourg	53,000	120,000	150,000
Other countries	96,000	525,000	670,000
Total	2,436,000	2,654,000	3,020,000

Sources: For Canada, Statistics Canada. For other countries, U.S. Bureau of Mines Minerals Yearbook, 1970 and U.S. Commodity Data Summaries, January, 1973.
. . Not available. [e] Estimated.

humans and animals. Sodium selenate finds application in the control of certain diseases in animals and poultry. The addition of selenium to a proportion of 0.5 ppm as sodium selenite to certain animal feed could open up a fairly important market.

A small amount of selenium is used in the manufacture of delay-action blasting caps.

Table 4. Canada, industrial use of selenium, 1970-72

	1970	1971	1972
	(pounds of contained selenium)		
By end-use			
Glass	12,000	11,200	15,400
Other[1]	3,600	4,500	5,300
Total	15,600	15,700	20,700

Source: Statistics Canada Consumers' Reports.
[1] Electronics, rubber, steel, pharmaceuticals.

Outlook

Selenium production is a function of copper mining and its output will closely follow the trend of copper. Depending on price and substitution the outlook for short term growth could range from zero to as much as 2.5 per cent per annum. Substitute materials are available for many of the applications and therefore demand will be extremely cost sensitive. Improvements in the recovery process could increase the supply.

Prices

The prices quoted in *Metals Week* for selenium in the United States remained steady throughout the year at $9 per pound for commercial grade and $11.50 per pound for high-purity.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92804-4	Selenium metal	5%	10%	15%

United States

Item No.		On and After January 1 1970	1971	1972
		(%)	(%)	(%)
632.40	Selenium metal, unwrought, other than alloys and waste and scrap	free	free	free
632.84	Selenium metal alloys, unwrought }	12.5	10.5	9
633.00	Selenium metals, wrought }			
420.50	Selenium dioxide }	free	free	free
420.52	Selenium salts }			
420.60	Selenium compounds, other	7	6	5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States Annotated 1972, T.C. Publication 452.

TELLURIUM

Like selenium, tellurium is recovered in Canada from the tankhouse slimes of the two electrolytic copper refineries and the Port Colborne nickel refinery. It is refined by the same two companies; Canadian Copper Refiners Limited at Montreal East, Quebec, and The International Nickel Company of Canada, Limited at Copper Cliff, Ontario.

Production of tellurium in all forms from Canadian ores in 1972 amounted to 48,000 pounds valued at $288,000, compared with 24,488 pounds in 1971 valued at $148,397. Refined output from all sources, including imported material, for the years 1972 and 1971 were 58,466 and 43,558 pounds respectively. Low production in 1971 occurred because tellurium refining at Canadian Copper Refiners was temporarily suspended to install additional pollution control equipment.

The major producers of tellurium from non-communist countries are the United States, Japan, Canada and Peru. The U.S.S.R. is also a producer of tellurium. Canada is a relatively small consumer of tellurium. Most of the production is exported, mainly to the United States.

Consumption and Uses

Tellurium is mainly recovered as a byproduct of copper refining and the supply is therefore related to copper production. Under present technological practices a low ratio of recovery is obtained but is adequate to meet demand. Tellurium and many of its compounds are highly toxic and great care is required in the handling of these materials. This could have a limiting effect on an expanding use.

Most of the commercial grade tellurium sold by the primary producers is in the form of slabs or sticks, tablets or powder. Also, it is sold as copper and iron alloys.

The primary metal industries are by far the largest consumers of tellurium. Added to low carbon and alloy steels, the machinability is greatly improved. In stainless steel castings it reduces or prevents pinhole porosity. A very small quantity of tellurium added to molten iron controls the chill depth of grey iron castings. An alloy containing 99.5 per cent copper – 0.5 per cent tellurium is used in the manufacture of welding, radio and communications equipment because it can be hot and cold worked and the thermal and electrical conductivity is only slightly less than that of copper. Up to 0.1 per cent tellurium in lead forms an alloy that has improved resistance to wear, vibration breakdown, and corrosion and because of these properties is used to sheath marine cables and in sulphuric acid equipment.

Tellurium is used as a secondary vulcanizing agent in natural and synthetic rubber. It increases toughness and resistance to abrasion and heat. These characteristics made possible its application for the jacketing of portable electric cable used in mining, dredging and welding and for specialized conveyor belting. Tellurium is employed to eliminate porosity in thick rubber sections and as an accelerator for butyl applications.

Some tellurium is consumed in components of thermoelectric devices; in glass and ceramic production to develop blue to brown coloration; in the preparation of insecticides and germicides; and in the

Table 5. Canada, tellurium production and consumption, 1971-72

	1971		1972^p	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Quebec	11,935	72,326	24,000	142,000
Ontario	8,100	49,086	8,000	51,000
Manitoba	3,596	21,792	12,000	74,000
Saskatchewan	857	5,193	4,000	21,000
Total	24,488	148,397	48,000	288,000
Refined[2]	43,558	..	58,446	..
Consumption (refined)	1,178	..	1,419	..

Source: Statistics Canada.
[1] Recoverable tellurium content of blister copper treated, plus refined tellurium from domestic primary material. [2] Refinery output from all sources, including imported material and secondary sources. [3] Available data, reported by consumers.
^p Preliminary.

Table 6. Canada, production and consumption of tellurium, 1962-71

	Production		Consumption
	All Forms[1]	Refined[2]	Refined[3]
	(pounds)		
1963	76,842	70,640[r]	1,853
1964	77,782	80,255	1,473
1965	69,794	71,730	1,870
1966	72,239	72,745	862
1967	73,219	70,105	981
1968	70,991	65,926	4,605
1969	62,048	72,664	3,532
1970	58,333	64,634	880
1971	24,488	43,558	1,178
1972[p]	48,000	58,446	1,419

Source: Statistics Canada.
[1]Includes recoverable tellurium content of blister copper, not necessarily recovered in year designated, plus refined tellurium from domestic primary metal. [2]Refinery production from all sources, including imported material and secondary sources. [3]Available data, reported by consumers.
[p]Preliminary; [r]Revised.

Table 7. Noncommunist world production of tellurium

	1970	1971	1972[e]
		(pounds)	
United States	158,000	164,000	200,000
Canada	58,000	24,000	48,000
Japan	78,000	79,000	85,000
Peru	62,000	53,000	55,000
Total	356,000	320,000	388,000

Sources: For Canada, Statistics Canada. For other countries, U.S. Bureau of Mines Minerals Yearbook, 1970; U.S. Bureau of Mines Commodity Data Summaries, January 1973.
[e]Estimated.

manufacture of delay-electric blasting caps and pigments.

Outlook

Supply will be largely limited to that which is available from copper output. Depending on price and substitution the outlook for short term growth could range from zero to as much as 2.5 per cent per annum. The readily available substitutes for the major uses could have an adverse effect on demand.

Price

According to *Metals Week*, the United States tellurium price throughout 1972 was $6 per pound for powder in 100-pound lots and for slab in 150-pound lots.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92804-5	Tellurium metal	5%	10%	15%

United States

Item No.		On and After January 1 1970	1971	1972
		(%)	(%)	(%)
632.48	Tellurium metal, unwrought, other than alloys, and waste and scrap (duty on waste and scrap suspended to June 30, 1973)	5.5	4.5	4
632.84	Tellurium metal alloys, unwrought }	12.5	10.5	9
633.00	Tellurium metal, wrought }			
421.90	Tellurium compounds }	7	6	5
427.12	Tellurium salts }			

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedule of the United States Annotated 1972, TC Publication 452.

Silica

G.H.K. PEARSE

Silica (SiO_2) occurs as the mineral quartz in a variety of rocks and unconsolidated sediments. Although the mineral is one of the most abundant, making up an estimated 12 per cent of the earth's crust, commercial sources of silica are presently restricted to uncommonly pure sands, sandstones, quartzites and vein quartz. Further, because of its low unit value, an economically viable deposit should be mineable by low-cost open-pit methods and, ideally, be located close to consuming areas in order to minimize transportation costs.

The principal uses for silica are: as the chief constituent in glass; as metallurgical flux; in the manufacture of silicon carbide; as an ore of silicon and ferrosilicon; as foundry sand for metal castings; in sand blasting; and as filler materials in tile, asbestos pipe, concrete blocks and bricks.

Production of silica in Canada in 1972 was 2.7 million short tons, an increase of 5.7 per cent over 1971, a year of strikes in the glass industry, technical difficulties at Indusmin Limited's Midland, Ontario operation and cutbacks in smelter output, primarily of nickel but also of copper and lead, with the consequent reduction in requirements for metallurgical flux. This tonnage remains short of the record 3.2 million tons shipped in 1970.

Most of the silica produced in Canada is low-value lump silica and silica sand consumed as a metallurgical flux. High-quality silica sand suitable for the manufacture of glass is produced by two companies in Canada. Indusmin Limited, the largest, operates beneficiation plants in southern Ontario and Quebec. Steel Brothers Canada Ltd. quarries high-grade silica sandstone on Black Island in Lake Winnipeg and processes the material at the company's plant located at Selkirk, Manitoba. This company acquired the quarry and plant from The Winnipeg Supply and Fuel Company, Limited in 1972.

Canada imports high-grade silica sand for use in glass manufacture along with substantial quantities of sand suitable for foundry castings. In 1972, imports virtually all from the United States, were 1.37 million tons, marginally lower than in 1971.

Some 20,000 tons of silica were imported from Belgium to supply Ahlstrom Canada Limited's glass container plant at Scoudouc, New Brunswick.

Principal producers and developments

Newfoundland. Newfoundland Enterprises Limited, a subsidiary of Armand Sicotte & Sons Limited, produces silica from a quarry at Villa Marie, on the Avalon Peninsula. The silica is hauled by truck about 12 miles to Long Harbour where it is used as a flux in the manufacture of elemental phosphorus by Electric Reduction Company of Canada, Ltd. (ERCO) (name change effective January 1, 1973 to Erco Industries Limited). ERCO's $40 million phosphorus plant requires about 100,000 tons of silica annually. Because of down time resulting from repeated breakage of electrodes, silica consumption was about half of normal operating requirements in 1971. The difficulty appears to have been overcome during 1972.

Quebec. Indusmin Limited produces a wide variety of silica products at its mill near St-Canut, Quebec. In addition to quarrying Potsdam sandstone adjacent to the St-Canut mill, the company quarries a friable Precambrian quartzite from a deposit near St-Donat. Material from the St-Donat quarry is trucked about 50 miles to the St-Canut mill for processing. Products produced at St-Canut include: silica sand suitable for glass and silicon carbide manufacture; foundry sand; silica flour for use as a filler in tiles, asbestos pipe, concrete blocks and bricks. The silica sand suitable for glass manufacture is marketed in Quebec while much of the product suitable for use in the construction industry is sold in Ontario. The balance of Quebec's silica sand requirements for glass manufacture is imported from the United States.

Union Carbide Canada Mining Ltd. quarries quartzitic sandstone at Melocheville, Beauharnois County, for use in ferrosilicon manufacture at Beauharnois. Fines from this operation are used in foundry work, in cement manufacture and as a metallurgical flux.

E. Montpetit et Fils Ltée quarries sandstone in the Melocheville area for use by Chromium Mining & Smelting Corporation, Limited, in the manufacture of ferrosilicon, also in Beauharnois.

Baskatong Quartz Products produces lump silica and crushed quartz from a deposit on the southwestern shore of Lake Baskatong. The lump silica is used in the manufacture of silicon metal and to a lesser extent as grinding pebble. The crushed quartz is sold for use as exposed aggregate in decorative concrete.

Ontario. Indusmin Limited quarries a high-grade silica deposit on Badgeley Island in Georgian Bay. The

Table 1. Canada, silica production and trade, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Production, quartz and silica sand[1]				
By province				
Quebec	599,898	3,444,175	835,000	4,400,000
Ontario	1,228,455	2,141,272	1,200,000	2,600,000
Manitoba	526,815	1,191,382	530,000	1,200,000
Newfoundland	..	215,553	..	250,000
British Columbia	37,188	160,000	50,000	210,000
Nova Scotia	..	115,200	..	90,000
Saskatchewan	90,169	72,301	–	–
Alberta	..	71,471	–	–
Total	2,553,884	7,411,354	2,700,000	8,750,000
By use				
Flux	1,754,321	2,513,611	..	..
Ferrosilicon	160,751	755,963	...	..
Glass and fibreglass	149,172	1,242,831	..	..
Other uses[2]	489,640	2,898,949	..	..
Total	2,553,884	7,411,354	2,700,000	8,750,000
Imports				
Silica sand				
United States	1,396,495	5,513,000	1,345,327	5,777,000
Belgium and Luxembourg	20,205	51,000	19,880	58,000
Norway	3,578	60,000	1,819	29,000
Sweden	–	–	1,819	29,000
Total	1,420,278	5,624,000	1,368,845	5,893,000
Silex and crystallized quartz				
United States	306	113,000	8	64,000
Brazil	....	2,000	1	...
Netherlands	6	2,000	–	–
Total	312	117,000	9	64,000
Firebrick and similar shapes, silica				
United States	10,234	1,702,000	4,071	844,000
West Germany	7,773	1,649,000	1,567	359,000
Total	18,007	3,351,000	5,638	1,203,000
Exports				
Quartzite				
United States	100,646	212,000	137,569	302,000
Dominican Republic	18	...	–	–
Total	100,664	212,000	137,569	302,000

Source: Statistics Canada.
[1]Producers' shipments, include crude and crushed quartz, crushed sandstone and quartzite and natural silica sand. [2]Includes foundry use, sand blasting, silica brick, concrete products, chemical manufacture, building products and silicon carbide. ^{p}Preliminary; –Nil; ..Not available for publication;...Less than one thousand dollars;. . . .Less than one ton.

deposit consists of very pure Precambrian Lorraine quartzite. A grinding and processing plant at Midland and a primary crushing plant at the deposit some 120 miles north of Midland across Georgian Bay, came on stream during the first half of 1970. The Badgeley Island operation has a capacity of approximately 1

Table 2. Canada, silica production and trade, 1963-72

	Production	Imports			Exports	Consumption
	Quartz and Silica Sand[1]	Silica Sand	Silex or Crystallized Quartz	Flint and Ground Flintstone	Quartzite	Quartz and Silica Sand
			(short tons)			
1963	1,836,612	787,157	11,887	1,812	47,437	2,413,498
1964	2,117,273	771,900	5,176	..	146,206	2,491,596
1965	2,433,685	834,780	5,104	..	111,533	3,156,466
1966	2,299,660	1,013,285	288	..	156,038	3,372,668
1967	2,610,740	952,459	142	..	56,200	3,501,186
1968	2,554,565	1,107,000	116	..	64,086	3,684,424
1969	2,300,374	1,285,228	35	..	81,488	3,526,264
1970	3,238,037	1,296,537	205	..	64,945	4,386,433
1971	2,553,884	1,420,278	312	..	100,664	
1972[p]	2,700,000	1,368,845	9	..	137,569	

Source: Statistics Canada.
[1]Includes silica to make silica brick.
[p]Preliminary; . . Not available.

million tons per year of washed lump silica and fine material. The Midland plant capacity is about 500,000 tons per year of refined silica products. Primary products from the crushing plant on Badgeley Island are shipped directly to manufacturers of ferrosilicon and silicon metal, and to the Midland grinding plant for further processing. Products from the Midland plant go to glass, ceramic, chemical and other industries in Ontario.

Output has been restricted at the Midland plant from the start because of difficulties experienced with the classification circuit. During 1971, the grinding unit output was little better than 50 per cent of rated capacity. The unit was converted from a rod mill to a ball mill and the efficiency of the plant was much improved. Alterations during 1972 resulted in further improvement raising output significantly.

Manitoba. Steel Brothers Canada Ltd. quarries friable sandstone of the Winnipeg Formation at Black Island in Lake Winnipeg. The sandstone is then barged to the company's processing plant at Selkirk where it is washed, sized and packaged for sale. The company provides silica sand for a large portion of the western Canada market. Silica sand suitable for the manufacture of glass containers is shipped to Alberta while the majority of the remaining production is consumed in the Manitoba market, largely as foundry sand. In addition to the silica sand operation, the company quarries quartzite and sand for The International Nickel Company of Canada, Limited's smelter at Thompson, Manitoba, for use as metallurgical flux.

British Columbia. Pacific Silica Limited ceased production of silica for ferrosilicon and silicon carbide in August 1968 at its deposit near Oliver, British Columbia. Stucco dash and roof chips are being produced from existing stockpiles.

Uses and specifications

The principal uses of lump silica, silica sand and crushed quartzite, together with specifications by consuming industry, are as follows:

Lump silica. *Silica flux.* Massive quartz, quartzite, sandstone and unconsolidated sands are used for flux in smelting base-metal ores where iron and basic oxides are slagged as silicates. Because free silica is the active slagging agent, the free silica content should be as high as possible. Minor amounts of impurities such as iron and alumina are tolerable. Lump silica used as a flux is usually minus one plus 5/16 inch in size.

Silicon and silicon alloys. Lump quartz, quartzite and well cemented sandstones are used in the manufacture of silicon, ferrosilicon and other silicon alloys. Lump silica 3/4 to 5 inches in size, obtained by crushing quartzite or indurated sandstone, is used in the manufacture of ferrosilicon. Chemical specifications are: silica, 98.0 per cent; alumina (Al_2O_3), less than 1.0 per cent; iron (Fe_2O_3) plus alumina, not over 1.5 per cent; lime and magnesia, each less than 0.2 per cent. Phosphorus and arsenic should be absent.

Silica brick. Quartz and quartzite crushed to minus 8 mesh are used in the manufacture of silica brick for high-temperature refractory furnaces. Chemical specifications for this use are: silica, 96 to 98 per cent; alumina, less than 0.1 per cent; combined iron and

Table 3. Canada, available data on consumption of silica, by industries, 1970

	(short tons)
Smelter flux[1]	2,321,376
Glass manufacture (incl. glass fibre)	618,511
Foundry sand	824,227
Artificial abrasives	169,683
Ferrosilicon	188,947
Metallurgical use	82,868
Concrete products	22,920
Gypsum products	12,784
Asbestos products	36,247
Chemicals	24,423
Fertilizers, stock, poultry feed	26,321
Other	58,126
Total	4,386,433

Source: Statistics Canada for source data. Classification by Statistics Section, Mineral Resources Branch.
[1] Producers' shipments of quartz and silica for flux purposes.

alumina, less than 1.5 per cent. Other impurities such as lime and magnesia should be low.

Aggregate. Crushed and sized quartz and quartzite are used as exposed aggregate in precast concrete panels for buildings, slabs, sidewalks and for other decorative landscape purposes. Colour and texture are important. Some architects prefer a white, opaque quartz, while others prefer a shiny, translucent variety.

Other uses. Lump quartz and quartzite are used as lining material in ball and tube mills and as lining and packing for acid towers. In some instances, naturally occurring quartzitic pebbles are used as grinding media in the crushing of various nonmetallic ores.

Silica sand. *Glass.* High-purity, naturally occurring sand or material produced by crushing quartzite or sandstone is used in the manufacture of glass.

Minor amounts of certain elements are particularly objectionable because they act as powerful colourants. For example, chromium should not exceed six parts per million and cobalt not over two parts per million.

Silicon carbide. Silica sand used in the manufacture of silicon carbide should have a silica content of at least 99 per cent. Iron and alumina should be less than 0.1 per cent each; lime, magnesia and phosphorus should be absent. Sand should be plus 100 mesh, with the bulk of it plus 35 mesh.

Hydraulic fracturing. Sand is used in the hydraulic fracturing of oil-bearing strata to increase open pore spaces, thus increasing the productivity of the oil well. Sand utilized for this purpose should be clean and dry, have a high compressive strength, be free of acid-consuming constituents and have a grain size between 20 and 35 mesh. Grains should be well rounded to facilitate placement in the formation in order to provide maximum permeability.

Foundry sand. Naturally occurring sand or material produced by the crushing of friable sandstones is used in the foundry industry for moulding. For foundry purposes, the chemical composition of the sand is not as important as its physical properties. For this end-use, a highly refractory sand having rounded grains with frosted or pitted surface is preferred. Grain sizes vary between 20 and 200 mesh. Rounded grains are preferable to angular fragments because they allow maximum permeability of the mould and maximum escape of gas during casting.

Sodium silicate. Sand for the manufacture of sodium silicate should contain more than 99 per cent silica, less than 0.25 per cent alumina, less than 0.05 per cent lime and magnesia combined and less than 0.03 per cent iron (Fe_2O_3). All sand should be between 20 and 100 mesh.

Other minor uses. Coarsely ground, closely sized quartz, quartzite, sandstone, and sand are used as abrasive grit in sandblasting and in the manufacture of sandpaper. Various grades of sand are used as filtering media in water-treatment plants; silica is also required in portland cement manufacture where there is insufficient silica in the limestone or other raw material used in the process.

Silica flour. Silica flour produced by the fine grinding of quartzite, sandstones and lump quartz, is used in the ceramics industry for enamel frits and pottery flint. For use in enamels, the silica flour must be over 97.5 per cent silica, with alumina (Al_2O_3) less than 0.5 per cent and iron (Fe_2O_3) less than 0.2 per cent. Silica flour is also used as an inert filler in rubber and asbestos cement products, as an extender in paints and as an abrasive agent in soaps and scouring pads. It is used increasingly in autoclave-cured concrete products such as building blocks and panels, approximately 45 pounds of silica flour being used for each 100 pounds of portland cement consumed.

Quartz crystal. Quartz crystal with desirable piezo-electric properties is used in radio-frequency control, radar and other electronic devices. Crystal for this purpose must be perfectly transparent and free from all impurities and flaws. The individual crystals should weigh 100 grams or more and measure at least 2 inches in length and 1 inch or more in diameter. Most of the world's crystal requirement is met by natural crystal from Brazil; however, natural crystal is being rapidly replaced by excellent quality, synthetic crystal grown in the laboratory from quartz 'seed'. Artificial quartz crystals are delivered already oriented for the cutter. The high degree of purity permits product yields at least four times that of natural quartz crystal.

There is no production of quartz crystal in Canada, where only a small demand exists. Domestic requirements are met largely by imports chiefly from the United States with minor amounts from Brazil. Quartz Crystals Mines Limited, Toronto, produced minor tonnages from an occurrence near Lyndhurst, Ontario, several years ago.

Outlook

Considerable progress has been made in overcoming difficulties experienced at Indusmin's Midland plant, and ERCO's phosphorus plant at Long Harbour appears to be running smoothly after a year of technical problems. Copper and lead smelting is expected to step up somewhat in 1973, recovering from 1971 production cutbacks. However, nickel output will remain about the same to draw down large inventories and the net increase on metallurgical silica consumption will be moderate. Total silica production in Canada is expected to exceed 3 million tons in 1973.

Tariffs

Canada

Item No.		
29500-1	Ganister and sand	free
29700-1	Silex or crystallized quartz, ground or unground	free

United States

Item No.		(¢ per lt)
513.11	Sand containing 95% or more silica, and not more than 0.6% of oxide or iron	
	On and after Jan. 1, 1970	35
	On and after Jan. 1, 1971	30
	On and after Jan. 1, 1972	25
513.14	Sand, other	free
514.91	Quartzite, whether or not manufactured	free
523.11	Silica, not specially provided for	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972), T.C. Publication 452.

Silicon and Ferrosilicon

D.D. BROWN

Canada exported 48,824 short tons of ferrosilicon in 1972 valued at $6,623,000, compared with 51,827 tons valued at $8,503,000 in 1971. Imports of ferrosilicon, principally from the United States and Norway, amounted to 9,564 tons valued at $2,663,000 in 1972 compared with 10,380 tons valued at $2,679,000 in 1971.

Silica (SiO_2) is the resource material from which silicon, ferrosilicon and silicon carbide are made; silica* is also an important raw material in making other industrial products and in many industrial in-plant processes.

World prices of ferrosilicon, silicon and other silicon products are expected to increase gradually over the next few years as a result of increasing electrical power, raw material, labour, and air-pollution abatement costs. No substitute materials are capable of performing the various metallurgical functions of ferrosilicon and silicon metal in the same low-cost range. The manufacture of these products depends primarily on the availability of low-cost electrical power although other economic and geographical factors are important. Average long-term growth in demand should be about 4 per cent a year.

Silicon is not a metal in the usual association of the term because it lacks ductility and electrical conductivity. It is solid, hard, and has a grey metallic lustre but is brittle and its conductivity is intermediate between that of conductors and insulators, the property of semiconduction important to its electronic applications.

Silicon in the form of ferrosilicon alloys and metallurgical silicon metal is the most extensively used deoxidizer in the making of most grades of carbon and alloy steels. Ferrosilicon alloys are also important silicon alloying elements used to improve the strength, hardenability and oxidation resistance of a wide variety of steels.

Silicon alloys include ferrosilicon, silvery pig iron, silicomanganese, ferroaluminum-silicon, ferrochromium-silicon, ferromanganese-silicon, calcium-silicon, calcium-manganese-silicon, barium-silicon, ferrozirconium-silicon and zirconium-silicon, all of which are used in metallurgical industries. Ferrosilicon accounts for the largest tonnage of silicon alloys produced. Silicon is used in alloys of iron, aluminum and copper and in the preparation of silicones, silicates and other chemical products.

Canada

Ferrosilicon is produced by Chromium Mining & Smelting Corporation, Limited (Chromasco) at its ferroalloy plant at Beauharnois, Quebec. Output consists primarily of 50, 75, 85 and 90 per cent silicon grades of ferrosilicon. One electric furnace with a power rating of 15,500-kva produces ferrosilicon; a second with a power rating of 5,500-kva produces silicon metal.

Union Carbide Canada Limited, Metals and Carbon Division, has four electric furnaces with a combined rating of 81,000 kva at its ferroalloy plant at Beauharnois, Quebec. Annual production capacity is about 75,000 short tons of silicon ferroalloys and silicon metal. Ferrosilicon in 45 to 90 per cent silicon grades, magnesium ferrosilicon, and silicon metal are the principal ferroalloys produced.

Both Union Carbide and Chromasco obtain high-quality quartzitic sandstone from a quarry at Melocheville near Beauharnois. The low-cost power rates, location on the St. Lawrence-Great Lakes waterway transport system, and access to nearby quartzite make Beauharnois a favourable production location. Union Carbide also obtains high-quality quartzitic sandstone from a quarry near Lac Baskatong in the Mont-Laurier area of Quebec.

Union Carbide also operates a ferrosilicon plant at Chicoutimi, Quebec, with a 35,000-kva electric furnace having an annual capacity of 25,000 tons of ferrosilicon. It produces ferrosilicon carrying 75 and 85 per cent silicon.

In addition to Chromasco and Union Carbide, there are five manufacturers that produce silicon carbide and a low-grade ferrosilicon containing 10 to 16 per cent silicon (Si).

Foreign

The United States is the world's largest producer and consumer of silicon and silicon ferroalloys for metallurgical use. In 1972, U.S. production of ferrosilicon amounted to about 627,000 short tons and production of metallurgical-grade silicon metal was about 116,000 short tons. Consumption of ferrosilicon and silicon metal was 501,911 and 64,450 tons, respectively.

* See Silica, No. 42 in 1972 Preprint Series of Mineral Reviews.

European Economic Community (EEC) production and consumption of ferrosilicon in 1972 were estimated at 404,800 and 477,400 short tons, respectively. Norway is the world's leading ferrosilicon exporter with exports of 234,020 short tons (75 per cent Si basis) in 1972; the expanded EEC, which includes the United Kingdom, accounts for some 60 per cent of Norway's export market.

Silicon in iron and steel

Silicon alloys include ferrosilicon, silvery pig iron, silicomanganese, ferrochromium-silicon, ferromanganese-silicon and other metal silicides, all of which are principally used in metallurgical industries. Ferrosilicon accounts for the largest tonnage of silicon alloys produced.

Silicon, introduced in the form of ferrosilicon and silicon metal into molten steel, is an effective and economical deoxidizer. In importance, silicon is second only to manganese in steelmaking as a ferroalloy additive; the latter deoxidizes steel and reduces its sulphur content.

Silicon additions of up to 0.3 per cent in standard alloy steels increase their tensile and yield strengths. At higher silicon contents, the hardenability of steel and its yield strength are increased with a loss of ductility and impact resistance. Probably the most important silicon-containing alloy steels are the electrical (sheet) steels. Silicon reduces to a minimum those oxides and carbides that have strong magnetic properties and for this reason, steel that is used for making electrical lamination sheets usually contains from 0.5 to 5.0 per cent silicon. Grain-oriented silicon steels are used in the construction of cores of transformers, generators and electric motors.

Silicon is added to stainless steels to improve the heat-resisting qualities of chrome, nickel-chrome and chrome-tungsten steels, and to improve their oxidation resistance at high temperatures.

Carbon steels for making springs usually contain 0.5 to 2.0 per cent silicon with 0.6 to 1.0 per cent manganese. Silicomanganese can be used to introduce both manganese and silicon to the metal.

The silicon content of iron is second only to its

Table 1. Canada, ferrosilicon, silicon carbide and some other ferroalloys,[1] exports and imports, 1971-72

	1971		1972	
	(short tons)	($)	(short tons)	($)
Exports				
Ferrosilicon				
Britain	28,139	4,280,000	25,421	3,540,000
United States	8,953	800,000	12,163	1,411,000
West Germany	55	14,000	4,982	724,000
Netherlands	3,201	677,000	3,222	292,000
Australia	1,516	380,000	611	183,000
Japan	132	50,000	401	145,000
Brazil	4,607	1,017,000	441	101,000
Angola	1,540	139,000	830	75,000
Other countries	3,684	1,146,000	753	152,000
Total	51,827	8,503,000	48,824	6,623,000
Silicon carbide, crude and grains				
United States	91,972	13,259,000	104,388	15,051,000
Brazil	1,102	188,000	-	-
Norway	603	130,000	-	-
Britain	182	16,000	-	-
Total	93,859	13,593,000	104,388	15,051,000
Ferroalloys, nes				
United States	2,584	876,000	1,128	1,492,000
Argentina	1	3,000	251	610,000
Britain	465	1,247,000	154	435,000
Venezuela	56	7,000	20	66,000
India	124	663,000	218	57,000
Australia	16	49,000	19	57,000
Belgium and Luxembourg	-	-	116	40,000
Other countries	152	100,000	993	164,000
Total	3,398	2,945,000	2,899	2,921,000

Table 1 (concl'd)

Imports				
Ferrosilicon				
United States	8,363	2,100,000	5,393	1,517,000
Norway	1,717	467,000	3,647	949,000
France	275	104,000	397	147,000
Italy	-	-	55	26,000
West Germany	19	6,000	58	19,000
Britain	6	2,000	14	5,000
Total	10,380	2,679,000	9,564	2,663,000
Silicomanganese, incl. silico spiegel				
United States	124	37,000	8,431	1,666,000
Norway	1,106	198,000	6,943	1,079,000
South Korea	-	-	907	152,000
Yugoslavia	-	-	356	63,000
South Africa	560	72,000	-	-
Total	1,790	307,000	16,637	2,960,000
Ferroalloys, nes				
United States	3,912	2,204,000	7,375	3,657,000
Brazil	108	289,000	2,368	1,099,000
Dominican Republic	-	-	938	984,000
South Africa	-	-	2,097	576,000
Britain	692	448,000	149	260,000
France	596	235,000	594	240,000
Chile	-	-	55	144,000
West Germany	115	41,000	110	44,000
Norway	-	-	91	32,000
Italy	-	-	11	32,000
Other countries	-	-	55	27,000
Total	5,423	3,217,000	13,843	7,095,000

Source: Statistics Canada.
[1] Important other ferroalloys are discussed in the mineral reviews of the respective metals, e.g., those of manganese, nickel, titanium.
nes Not elsewhere specified; - Nil.

carbon content in regard to its effectiveness in controlling the properties of iron castings. Cast iron usually contains less than 3.0 per cent silicon.

The amount of gases, chiefly oxygen, dissolved in liquid steel and the amount of gases released during solidification determine the types of ingots: semi-killed, capped and rimmed. The amount of oxygen dissolved in molten steel depends on the carbon content of the steel and upon the type and amount of deoxidizers added to the steel. The several types of ingot steel produced are determined by different steelmaking practices and the final structure of a steel ingot is determined by the degree to which the steel from which it was poured has been deoxidized.

The term 'killed' indicates that steel has been deoxidized sufficiently for it to lie perfectly quiet when poured into an ingot mould. The amount of silicon added to a killed steel will be from about 0.1 to 0.5 per cent. The other three types require lesser

Table 2. Ferrosilicon consumption and steel production in Canada, 1962-72

	Crude Steel Production	Ferrosilicon Consumption
	(st)	(lb/ton steel)
1962	7,173,000	3.6
1963	8,190,000	3.6
1964	9,128,000	3.8
1965	10,068,000	4.2
1966	10,020,000	4.4
1967	9,701,000^r	3.8
1968	11,198,000^r	4.2
1969	10,048,000^r	4.9^r
1970	12,249,000^r	4.6^r
1971	12,170,000	4.3
1972^p	13,073,000	..

Source: Statistics Canada.
^{p} Preliminary; ^{r} Revised; .. Not available.

Table 3. Canada, consumption, exports and imports of ferrosilicon, 1963-72

	Consumption	Exports		Imports	
	(st)	(st)	($)	(st)	($)
1963	24,182	36,736	3,705,201	3,826	1,159,414
1964	27,275	45,987	4,525,306	3,433	892,938
1965	33,811	46,424	4,706,724	6,260	1,799,546
1966	37,664	38,023	3,784,105	5,877	1,629,368
1967	34,807	41,929	4,189,328	21,740	3,534,000
1968	51,449	47,215	5,424,665	9,816	2,615,000
1969	50,737	48,499	5,257,000	9,050	2,010,000
1970	55,728	49,984	8,284,000	10,446	2,386,000
1971	43,619	51,827	8,503,000	10,380	2,679,000
1972^p	. .	48,824	6,623,000	9,564	2,663,000

Source: Statistics Canada.
^{p} Preliminary; . . Not available.

Table 4. Canada, ferrosilicon, consumption in the steel industry, 1962-71

	High Silicon (over 55% Si)	Medium Silicon	Low Silicon (under 45% Si)	Sil-X	Total
			(short tons)		
1962	1,691	11,222	44	54	13,011
1963	2,009	12,587	65	62	14,723
1964	1,987	15,294	159	71	17,511
1965	3,326	17,774	205	94	21,399
1966	3,914	17,828	130	88	21,960
1967	3,585	14,467	234	9	18,295
1968	5,783	15,788	1,841	13	23,425
1969	7,173	15,454	1,847	11	24,485
1970	7,154	17,965	2,877	7	28,003
1971	8,026	15,520	2,891	17	26,454

Source: Statistics Canada, Annual Report, Iron and Steel Mills.

amounts, down to nil or 0.05 per cent in a rimmed steel which evolves considerable gas in the ingot mould as the remaining oxygen reacts with carbon.

Ferrosilicon and silicon alloys

Ferrosilicon properly contains from 45 to 95 per cent silicon. Silvery pig iron is made in blast furnaces and contains up to 12 per cent silicon. Byproduct ferrosilicon from the manufacture of a silicon carbide abrasive in electric resistance furnaces contains from 16 to 18 per cent silicon.

The lower grades of ferrosilicon (below 25 per cent Si) are not suitable for ladle addition because the large amount required would have an excessive chilling effect on steel; they are used as bath (melt) additions and are available in the form of pigs or coarse lumps. The most extensively used silicon alloy is 50 per cent ferrosilicon. It is used as a deoxidizer and alloying agent in the production of killed and semikilled steels. The 65 per cent ferrosilicon is used as a ladle addition when the endothermic effect of the lower grade cannot be tolerated. The 75 and 90 per cent ferrosilicon grades are used for high-alloy steels requiring large additions of silicon. The 85 per cent grade is used mainly by cast-iron foundries. Sil-X is a briquetted mixture of ferrosilicon and sodium nitrate which is highly exothermic when added to the steel bath.

The low-aluminum grade (0.40 per cent Al maximum) 50 per cent ferrosilicon is used as a source of silicon for electrical steels containing less than 2 per cent silicon.

High-silicon ferrosilicon is also used in the silicothermic method of producing low-carbon ferroalloys, such as ferromolybdenum, ferrotungsten and ferrovanadium.

Table 5. Canada, ferrosilicon production,[1] 1963-71

	Ferrous Industry	Other Industries[2]	Total
	(short tons)		
1963	71,332	13,263	84,595
1964	86,548	12,660	99,208
1965	81,114	14,907	96,021
1966	76,943	16,547	93,490
1967	82,354	12,609	94,963
1968	82,710	10,392	93,102
1969	104,890	12,599	117,489
1970	114,635	8,914	123,549
1971	..	..	..

Source: Statistics Canada.
[1] Producers' shipments. [2] Principally abrasives industry byproducts.
.. Not available at time of publication.

Table 6. Ferrosilicon production and trade, 1970

	Production	Imports	Exports
	(short tons, gross weight)		
Austria	..	16,369	..
Belgium-Luxembourg	..	41,546	..
Canada	..	10,446	49,984
France	189,597	..	52,253
West Germany	..	151,116	16,242
India	28,809	..	8,504
Italy	85,994	27,484	..
Japan	333,223	24,640	..
Norway	241,296	-	238,583
South Africa	..	..	11,608
Spain	32,248	..	..
Sweden	51,632	19,183	21,665
United Kingdom	..	126,650	..
United States	709,287	22,404	33,106
U.S.S.R.	..	..	137,677

Sources: *Metal Bulletin Handbook*, Fifth Edition, 1972; for Canada, Statistics Canada; for U.S., Bureau of Mines *Minerals Yearbook* Preprint 1971.
.. Not available; - Nil.

Magnesium ferrosilicon containing about 9 per cent magnesium, 42 to 46 per cent silicon and 0.3 per cent cerium is used in making ductile iron and pipeline steel.

Silicon carbide

Silicon carbide is essentially a manufactured abrasive but very small amounts are also used in ferrous metallurgy as a deoxidant. When it is added to molten metal a vigorous exothermic reaction results from the oxidation of both silicon and carbon to produce a hotter melt. The silicon carbide addition produces a more random dispersion of graphite flakes to give a more machinable cast iron.

Silicon metal

Silicon metal having a purity of approximately 98 per cent silicon is obtained by carbon reduction of high-purity silica material in the submerged-arc electric furnace. Over half of silicon metal output is used as a deoxidizer in the production of steel. Most of the remainder is used in the manufacture of aluminum alloys by permanent mould and die-casting operations. It is alloyed in amounts ranging up to 13 per cent with aluminum to improve such casting qualities as fluidity during casting and freedom from hot-shrinkage and hot-cracking. Silicon also increases the corrosion resistance, hardness and tensile strength of aluminum alloys to provide improved impact toughness and resistance to friction. Silicon metal is alloyed with copper to produce silicon bronzes with up to 3 per cent silicon. Such alloys have good working qualities and excellent corrosion resistance. Silicon metal can be used as a ladle addition to deoxidize steel and serve as an alloying element in the production of steel and iron castings.

Because of its unique chemical characteristics, silicon metal is a basic raw material in the production of silicon-type lubricants, hydraulic fluids, resins, plastics, enamels and rubber. Purified silicon metal possesses semiconductive properties suitable for use in miniaturized electronic circuits.

Table 7. Canada, manufacturers' shipments of silicon carbide, 1961-71

	Crude Silicon Carbide	
	(short tons)	($)
1961	79,188	12,478,000
1962	65,853	10,233,000
1963	78,370	11,040,000
1964	85,433	11,398,000
1965	98,545	13,967,000
1966	108,351	14,777,000
1967	96,212	13,564,000
1968	109,174	16,192,000
1969	108,197	15,815,000
1970	114,764	17,653,000
1971	..	..

Source: Statistics Canada.

Table 8. Canada, exports of silicon carbide, 1962-72

	(short tons)	($)
1962	62,765	9,343,177
1963	72,905	9,855,821
1964	81,058	10,625,294
1965	90,902	12,243,784
1966	98,878	12,831,523
1967	87,166	11,461,930
1968	102,924	14,690,146
1969	103,501	14,974,000
1970	105,996	15,976,000
1971	93,859	13,593,000
1972p	104,388	15,051,000

Source: Statistics Canada.
p Preliminary.

Raw material specifications

The essential raw material for the metallurgical production of silicon and silicon alloys is silica in the form of quartz usually as quartzite or sandstone. The material should meet the following chemical specifications: SiO_2, about 98 per cent; alumina (Al_2O_3), less than 1 per cent; iron oxide (Fe_2O_3) plus alumina, less than 1.5 per cent; and lime and magnesia, each less than 0.2 per cent. Phosphorus should be less than 0.003 per cent and arsenic should be absent even as a trace element. An iron content of less than 0.5 per cent is required if the material is used to produce silicon metal for addition to aluminum. For larger furnaces, the material should be sized between 1 and 4½ inches and contain no fines. Silica containing occluded water and chert or chalcedony which also contain combined water are not desirable since they will decrepitate upon heating in the electric furnace.

Prices

Prices published by Metals Week in December 1971 and 1972

		1971 and 1972
		(U.S. ¢)
Ferrosilicon, pound contained silicon fob shipping point, freight equalized to nearest main producer, carload lots, lump bulk		
High-purity	(% Si)	
	75	19.6
	85	20.3
	90	20.3
Regular	50	16.0
Silicon metal, pound contained silicon, fob shipping point, freight equalized to nearest main producer, carload lots, lump bulk		
(% max. Fe)	(% max. Ca)	
0.35	0.07	25.4
0.50	0.07	23.7
1.00	0.07	21.5
Magnesium ferrosilicon 44/48 Si		
(% Mg)	(% Ce)	
9		23.95
9	0.5	26.25
5	0.5	19.80
35-40 zirconium silicon		33.75

Prices published by American Metal Market in December 1971 and 1972

	1971 and 1972
	(U.S. ¢)
SMZ alloy: 60-65% Si, 5-7% Mn 5-7% Zr, 15-ton lots, per pound of alloy	23.0
Calcium-silicon and calsibar alloy, fob producer, 15-ton lots, per pound	24.75
Electric furnace silvery pig iron, fob Niagara Falls	(U.S.$)
16% Si, per ton	90.00
22% Si, per gross ton	106.00

Tariffs

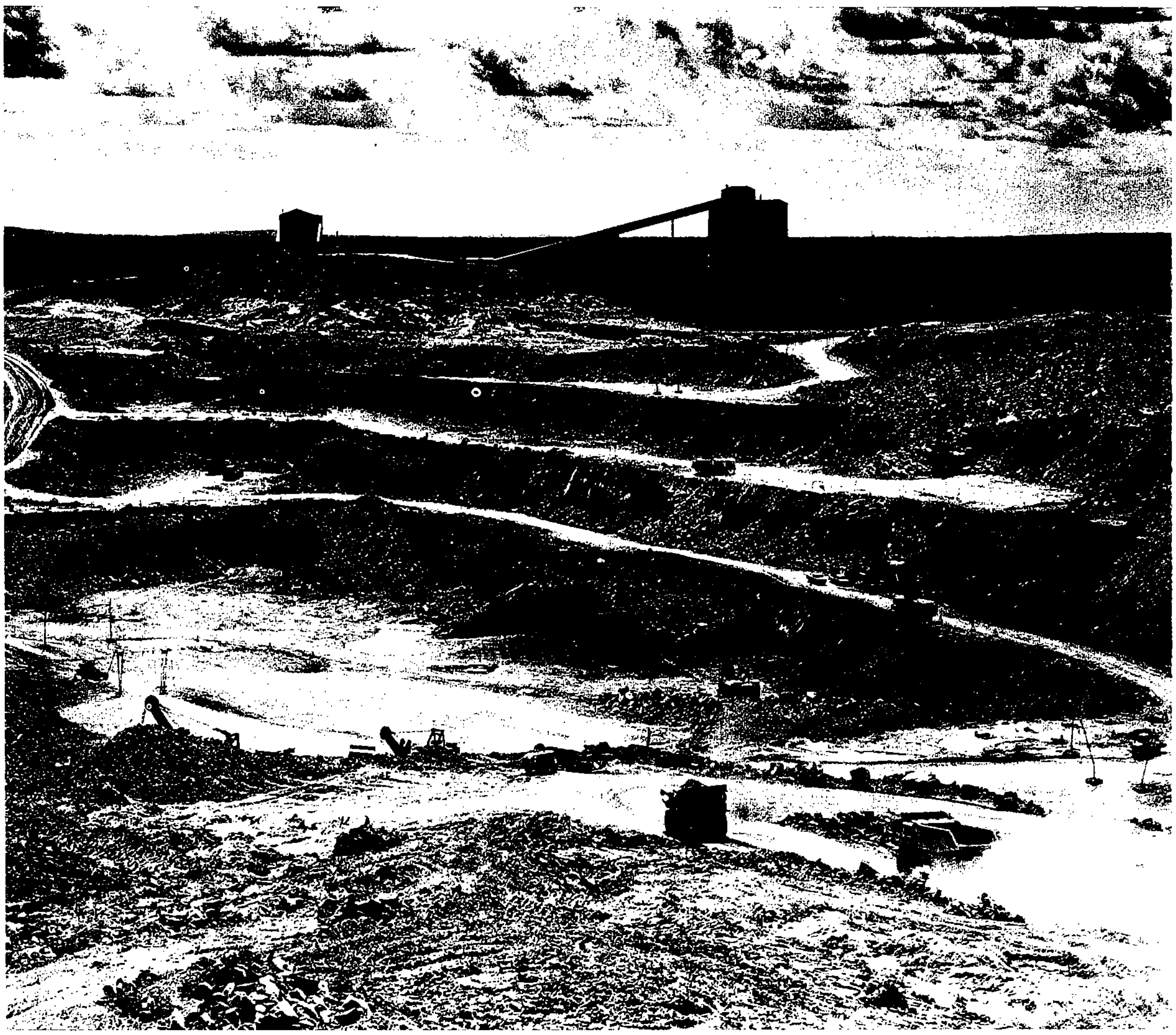
Canada Item No.		British Preferential	Most Favoured Nation	General
	Ferrosilicon, an alloy of iron and silicon, effective June 4, 1969		(¢)	(¢)
37503-1	containing 8% or more by weight of silicon and less than 60% per pound, or fraction thereof	free	free	1.75
37504-1	containing 60% or more by weight of silicon and less than 90% per pound, or fraction thereof, on the silicon contained therein	free	0.75	2.75
37505-1	containing 90% or more by weight of silicon per pound, or fraction thereof, on the silicon contained therein	free	2½	5½

Tariffs (concl'd)

United States

Item No.		On and After January 1 1971	1972
		(¢)	(¢)
	Ferrosilicon, per pound Si content		
607.50	containing over 8% but not over 60% by weight of silicon	0.1	free
607.51	containing over 60% but not over 80% by weight of silicon	0.55	0.5
607.52	containing over 80% but not over 90% by weight of silicon	1.2	1
607.53	containing over 90% by weight of silicon	2.4	2
607.55	Ferrosilicon chromium	10%	10%
607.57	Ferrosilicon manganese per pound Mn content	0.56¢ + 4.5%	0.46¢ + 3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa, Tariff Schedules of the United States, Annotated (1972), TC Publication 452.



An aerial view of Kidd Creek Mines, Timmins, Ontario, owned and operated by Ecstall Mining Limited, a wholly-owned subsidiary of Texas Gulf Sulphur Company. (George Hunter photo).

Silver

J.G. GEORGE

Canada's mine production of silver in 1972, 48,488,000 troy ounces*, was 2.46 million ounces greater than in 1971 and the highest on record. The increase was mainly attributable to greater output of several base-metal mines which produce silver as a byproduct, including the output of six mines that began operations in 1972, particularly Mattabi Mines Limited in Ontario and Nadina Explorations Limited in British Columbia. Significantly higher production by Terra Mining and Exploration Limited at its silver-copper property near Port Radium in the Northwest Territories also contributed to the greater Canadian output. Declines in production in Nova Scotia, Quebec, British Columbia and the Yukon Territory were more than offset by higher output in the other provinces and the Northwest Territories. Ontario was again, by far, the leading silver-producing province, primarily because of the substantial byproduct silver produced at the Kidd Creek base-metal mine of Ecstall Mining Limited near Timmins. Output in the Cobalt-Gowganda area of Ontario was somewhat less than in 1971. The value of Canadian production was $80.5 million, almost $8.7 million more than in 1971 because of higher prices and greater output.

Canada's exports of silver in ores, concentrates and as refined metal totalled 42,024,104 ounces in 1972, or some 1.7 million ounces less than the corresponding amount in 1971. The United States continued to be the major market, importing almost 77 per cent of Canada's total exports. Canadian imports of refined silver increased from 722,815 ounces in 1971 to 1,116,875 ounces in 1972. Virtually all of the imports came from the United States with a very minor quantity coming from the United Kingdom.

Total Canadian consumption of silver in 1972 has been preliminarily estimated at 8,401,383 ounces compared with 7,050,956 ounces in 1971.

Domestic production

Mine production. The principal source of silver was again base-metal ores, which accounted for almost 86 per cent of total production. The major portion of the remaining 14 per cent came from silver-copper and silver-cobalt ores mined near Port Radium in the Northwest Territories and in the Cobalt district of northern Ontario, respectively, and the balance was byproduct recovery from lode and placer gold ores. The principal mine producers of silver in Canada are listed in Table 4 and the accompanying map shows their approximate locations. The four largest producers in declining order of output were Ecstall Mining Limited in Ontario, Cominco Ltd. (Sullivan mine) in southeastern British Columbia, Anvil Mining Corporation Limited in the Yukon Territory and Brunswick Mining and Smelting Corporation Limited (No. 12 mine) in the Bathurst area of New Brunswick. Base-metal ores mined by these four producers accounted for some 45 per cent of total Canadian silver production. The largest producer in the Cobalt-Gowganda area of Ontario was again Teck Corporation Limited, Silverfields Division, with output of 1,343,918 ounces.

Metal production. Production of refined silver in 1972 at the six Canadian primary silver refineries was as follows:

	Production[1], Refined Silver	Annual Rated Capacity[2]
	(ounces)	
Brunswick Mining and Smelting Corporation Limited, Smelting Division, Belledune, N.B.	1,562,790	2,000,000
Canadian Copper Refiners Limited, Montreal East, Quebec	14,291,000	13,000,000
Cominco Ltd., Trail, B.C.	6,948,882	15,000,000
Kam-Kotia Mines Limited, Refinery Division[3] Cobalt, Ont.	..	15,000,000
Royal Canadian Mint, Ottawa, Ont.	228,000	7,000,000[4]
The International Nickel Company of Canada, Limited, Copper Cliff, Ont.	1,930,000[5]	..

[1]Figures obtained from company annual reports. [2]January 1, 1972. [3]Only a little refined silver was produced before plant's closure Feb. 1972. [4]Total capacity for producing refined gold and silver, of which about 10% is silver. [5]Silver delivered to markets.
..Not available.

*Wherever used in this review, the term "ounce" refers to the "troy ounce".

Table 1. Canada, silver production, trade and consumption, 1971-72

	1971		1972^p	
	(ounces)	($)	(ounces)	($)
Production[1]				
By province and territories				
Ontario	18,681,633	29,143,347	20,234,000	33,588,000
British Columbia	7,674,186	11,971,730	7,238,000	12,015,000
Yukon Territory	5,747,703	8,966,417	5,620,000	9,330,000
New Brunswick	5,057,627	7,889,898	5,430,000	9,013,000
Northwest Territories	2,932,446	4,574,616	4,399,000	7,303,000
Quebec	4,378,011	6,829,697	3,542,000	5,880,000
Manitoba	694,298	1,083,105	814,000	1,351,000
Newfoundland	563,604	879,222	810,000	1,344,000
Saskatchewan	238,763	372,470	401,000	665,000
Nova Scotia	55,292	86,256	–	–
Alberta	7	11	–	–
Total	46,023,570	71,796,769	48,488,000	80,489,000
By source				
Base-metal ores	43,136,068	67,292,266	45,957,000	76,288,000
Gold ores	294,301	459,109	226,000	375,000
Silver-cobalt ores	2,592,171	4,043,787	2,304,000	3,824,000
Placer gold ores	1,030	1,607	1,000	2,000
Total	46,023,570	71,796,769	48,488,000	80,489,000
Refined silver	20,284,699	. .	22,740,796	. .
Exports				
In ores and concentrates				
United States	16,266,628	23,052,000	14,141,017	19,471,000
Japan	4,957,813	6,881,000	4,319,055	5,835,000
West Germany	1,711,302	1,827,000	1,637,129	1,207,000
Belgium and Luxembourg	1,053,482	1,296,000	737,252	697,000
Peru	283,960	350,000	279,328	387,000
Italy	243,015	197,000	223,066	209,000
United Kingdom	250,421	312,000	208,504	204,000
Others	795,958	834,000	653,278	518,000
Total	25,562,579	34,749,000	22,198,629	28,510,000
Refined metal				
United States	16,795,421	25,865,000	18,173,883	29,805,000
Belgium and Luxembourg	1,162,649	1,959,000	1,191,342	1,673,000
Trinidad-Tobago	4,355	7,000	204,851	346,000
Jamaica	2,569	4,000	149,844	295,000
West Germany	231,372	400,000	88,022	124,000
United Kingdom	401	4,000	3,080	10,000
Other countries	4,604	8,000	14,453	27,000
Total	18,201,371	28,247,000	19,825,475	32,280,000
Imports				
Refined metal				
United States	705,901	1,165,000	1,116,434	1,962,000
United Kingdom	16,914	30,000	441	1,000
Total	722,815	1,195,000	1,116,875	1,963,000

Table 1 (concl'd)

	1971		1972^p	
	(ounces)	($)	(ounces)	($)
Consumption, by use				
Coinage	208,336		187,142	
Silver salts	458,350		557,935	
Silver alloys	693,563		931,874	
Sterling	1,434,101		2,066,193	
Wire and rod	28,981		36,105	
Other[2]	4,227,625		4,622,134	
Total	7,050,956		8,401,383	

Source: Statistics Canada.
[1]Includes silver: recoverable in ores, concentrates and matte shipped for export; in crude gold bullion produced; in blister and anode copper produced at Canadian smelters; in base bullion produced from domestic ores; and bullion produced from the treatment of domestic silver-cobalt ores at Cobalt, Ontario.
[2]Includes sheet and miscellaneous uses.
[p]Preliminary; – Nil; . . Not available.

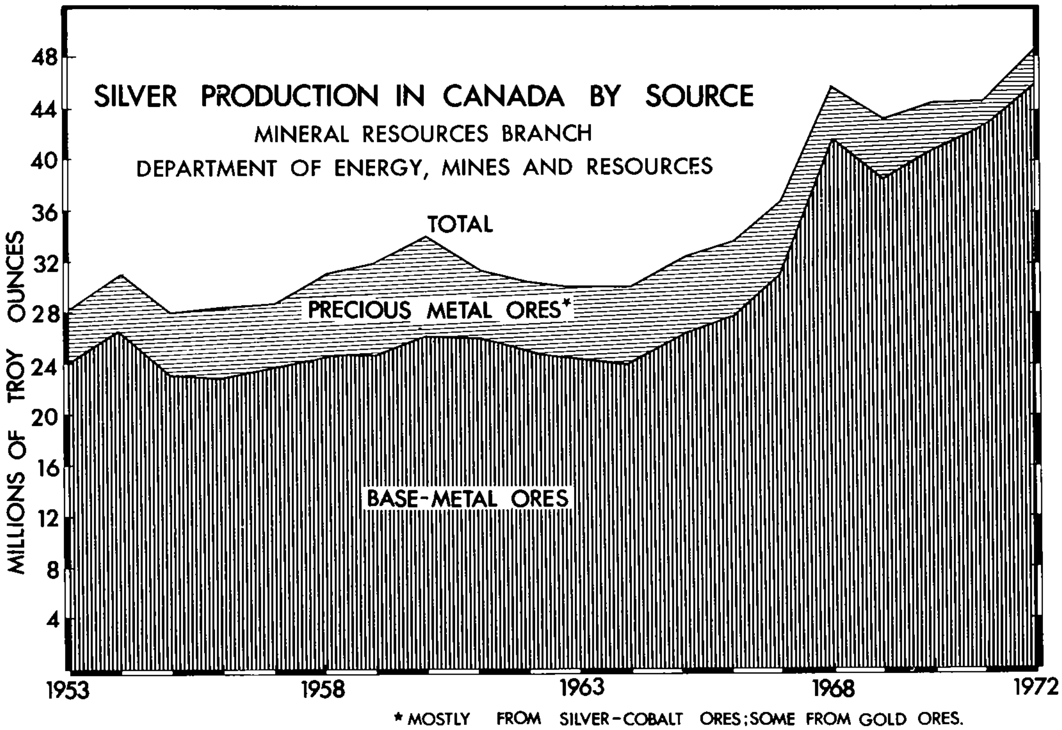
Table 2. Canada, silver production, trade and consumption, 1963-72

	Production		Exports				
	All Forms[1]	Refined Silver	In Ores and Concentrates	Refined Silver	Total	Imports, Refined Silver	Consumption,[2] Refined Silver
1963	29,932,003	19,772,408	8,286,756	10,834,629	19,121,385	7,950,972	17,574,628
1964	29,902,611	20,744,682	9,478,317	10,583,439	20,061,756	5,197,764	18,775,307
1965	32,272,464	20,630,190	12,245,877	11,268,110	23,513,987	13,413,434	30,170,097
1966	33,417,874	21,298,325	11,850,469	12,221,142	24,071,611	14,477,787	21,303,704
1967	36,315,189	20,658,556	10,407,418	13,735,675	24,143,093	5,383,872	14,576,608
1968	45,012,797	34,611,344	21,502,022	28,104,562	49,606,584	14,060,635	13,598,358
1969	43,530,941	38,678,520	21,883,028	34,658,937	56,541,965	19,168,785	5,747,068
1970	44,250,804	30,725,450^r	21,819,924	24,199,524	46,019,448	4,319,357	6,034,028
1971	46,023,570	20,284,699	25,562,579	18,201,371	43,763,950	722,815	7,050,956
1972^p	48,488,000	22,740,796	22,198,629	19,825,475	42,024,104	1,116,875	8,401,383

Source: Statistics Canada.
[1]Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; base bullion produced from domestic ores; bullion produced from the treatment of silver-cobalt ores at Cobalt, Ontario.
[2]Includes consumption for coinage.
[p]Preliminary; [r]Revised.

Canadian Copper Refiners Limited at Montreal East, Quebec, was again Canada's largest producer of refined silver, recovering it from the treatment of anode and blister copper. The silver refinery of Cominco Ltd. at Trail, British Columbia, was the second-largest producer, recovering byproduct silver in the processing of lead and zinc ores and concentrates. Other producers of refined silver were The International Nickel Company of Canada, Limited, at Copper Cliff, Ontario (from nickel-copper concentrates); and the Royal Canadian Mint at Ottawa, Ontario (from gold bullion). At Belledune, New Brunswick, Brunswick Mining and Smelting Corporation Limited, Smelting Division, recovered byproduct silver bullion from lead-zinc concentrates treated in a blast furnace*. Late in 1970 Kam-Kotia Mines Limited, Refinery Division, decided for economic

* Very little zinc concentrate was processed in 1972 as the furnace was being converted from an Imperial Smelting Process (ISP) furnace to a conventional lead blast furnace processing lead concentrates only.



reasons to close down its silver refinery at Cobalt, Ontario. The local mines concerned were notified that no shipments of ores or concentrates would be received after March 31, 1971, and the refinery was finally closed down in February 1972.

At its electronic materials plants at Trail, B.C., Cominco Ltd. also produces high-purity silver metal with metallic impurities totalling one part per million or less. This specialty metal product is manufactured mainly for applications in the electronics industry such as solder preforms, brazing preforms and lead wire.

World production, consumption and economic factors

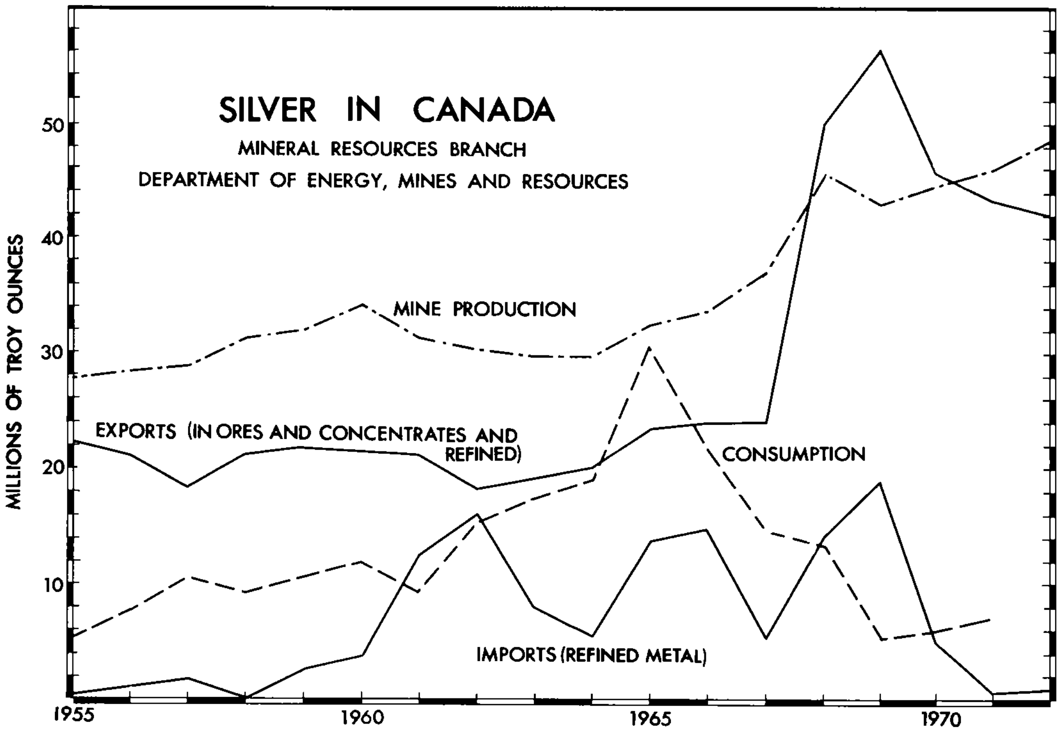
Silver production in the noncommunist world in 1972, according to an estimate of Handy and Harman*, was 243.0 million ounces, or 5.7 million ounces less than in 1971. In 1972 noncommunist world consumption for both industrial and coinage uses, excluding requirements for United States coinage which are supplied from Treasury stocks, was 420.2 million ounces. The gap between new production and consumption, not including the United States coinage requirements, was some 177 million ounces, or considerably more than in 1971.

Consumption of silver for coinage in the noncommunist world, excluding the United States, was 38.2 million ounces, or about 13.4 million ounces more than in 1971. The increase resulted mainly from substantial amounts of silver used by West Germany for a special minting of coins commemorating the Olympic games. Except for minor quantities in the minting of silver dollars for numismatists, silver has not been used in the production of Canadian coinage since 1968 when the Royal Canadian Mint consumed 7.4 million ounces.

Based on preliminary figures, Canada in 1972 was again the world's largest mine producer of silver; other leading producers were Peru, the U.S.S.R., the United States and Mexico.

New production of silver in the United States declined from 41.6 million ounces in 1971 to an estimated 37.9 million ounces in 1972. The decrease was mainly attributable to reduced output at the Sunshine mine of Sunshine Mining Company in Idaho which was shut down in May 1972 because of a disastrous fire. Although the mine, the largest individual mine producer of silver in the United States, has

* *The Silver Market 1972,* compiled by Handy and Harman.



since reopened, it will not be back in full operation until some time in 1973. In the United States, the world's largest silver consumer, consumption for industrial uses and coinage was 142.0 and 2.3 million ounces, respectively, in 1972. The large deficit in requirements was again met by imports, demonitized coinage, secondary silver derived from discarded jewelry, silverware, etc., liquidation of speculative holdings and withdrawals from United States Treasury stocks. Requirements for United States coinage were again obtained from Treasury stocks which (in the form of bullion, coin bars and coinage metal fund silver) declined during 1972 from 48.0 to 45.8 million ounces, excluding 139.5 million ounces contained in the strategic stockpile and 8.9 million ounces held by the Department of Defense. Although the stockpile objective remained unchanged at 139.5 million ounces, under plans announced by the United States administration in March 1973 it was proposed that the objective be reduced to 22.0 million ounces. Of the suggested reduction of 117.5 million ounces it was reported that some 110,000,000 ounces would be sold to U.S. industrial consumers and the remaining 7,500,000 ounces would be held for potential U.S. coinage requirements. However, Congressional reaction to the proposed stockpile reduction and the rate of its disposal have yet to be determined.

In May 1971 the United States Mint began the minting of 150 million Eisenhower dollar coins containing 40 per cent silver. Production of these commemorative coins was authorized in a provision included in Public Law PL-91-607 signed by President Nixon on December 31, 1970. The use of the metal in these special coins will not have any significant effect on the silver market as the United States Treasury Department, in 1970, had already set aside the silver (about 47 million ounces) that will be required. Part of these requirements resulted from a transfer of 25.5 million ounces from the strategic stockpile to the United States Mint, also authorized in Public Law PL-91-607. Some 2.28 million ounces of silver was consumed in the minting of the Eisenhower dollar coins in 1972, compared with 2.47 million ounces used in 1971.

In October 1972 the United States Treasury Department re-entered the silver market when it sold some 237,000 ounces of refined silver on a competitive bid basis. This silver, which resulted from reclamation activities of the Veterans Administration, was sold by General Services Administration (GSA) which had not made any sales of silver since November 1970. Late in 1972 GSA also began an unprecedented sale of some 2.9 million uncirculated 90 per cent silver dollars, most of them minted in Carson City, Nevada,

Table 3. World production[1] of silver, 1971-72

	1971^p	1972^e
	(ounces)	
Canada	46,024,000	48,500,000
Peru	38,398,000	39,000,000
U.S.S.R.^{e}	39,000,000	. .
United States	41,564,000	37,900,000
Mexico	36,657,000	34,000,000
Australia	21,615,000	. .
Japan	11,540,000	. .
Bolivia	6,800,000[2]	. .
Chile	5,360,000	. .
East Germany^e	5,000,000	. .
Sweden	4,823,000	. .
Honduras	3,642,000	. .
Republic of South Africa	3,378,000	. .
Yugoslavia	3,354,000	. .
Other countries	27,628,000	133,000,000
Total	294,783,000	292,400,000

Sources: Statistics Canada for Canada for 1971 and 1972. Other 1971 statistics from U.S. Bureau of Mines *Minerals Yearbook 1971*. Other 1972 statistics from U.S. Bureau of Mines Commodity Data Summaries, January 1973.
[1]Recoverable content of ores and concentrates produced unless otherwise noted. [2]Production by the state mining company, Corporacion Minera de Bolivia (COMIBOL), plus exports of medium and small (private sector) mines.
^{p}Preliminary; ^{e}Estimate; . . Not available.

between 1878 and 1891 and stored in Treasury vaults.

In 1972 the downward trend in world silver prices, which had prevailed during the previous four years, was dramatically reversed. Increasing industrial demand and speculative activity, together with a decline in visible stocks, were the main factors which caused a sharp rise in prices. The rise might have been more pronounced in the first half of the year had it not been for the price controls which obtained in the United States. Under the government's economic controls domestically produced silver had been subject to a ceiling price of $1.616 an ounce since August 16, 1971. In August 1972, however, the United States government's Cost of Living Council (CLC) recognized the international character of the silver market by removing the price controls which had applied to domestically produced silver in ores and concentrates, refined shapes, coins or other forms sold for manufacturing or professional uses.

On the New York Commodity Exchange (Comex), the principal futures market for contracts in silver in the United States, the volume of trading in silver in 1972 amounted to 815,168 contracts of 10,000 ounces each, compared with 616,244 contracts of 10,000 ounces each traded in 1971. As similar evidence of increasing speculative interest, the volume of silver traded on the Chicago Board of Trade in 1972 amounted to 754,045 contracts of 5,000 ounces each, compared with 511,391 contracts of 5,000 ounces each traded in 1971. Silver traded on the London Metal Exchange was 388,860,000 ounces in 1972 compared with 309,490,000 ounces in 1971.

New York Commodity Exchange (Comex) silver stocks at the end of 1972 were 77.56 million ounces compared with 115.45 million ounces at December 31, 1971. Chicago Board of Trade stocks at the end of 1972 were 22.81 million ounces compared with 13.02 million ounces at December 31, 1971. London Metal Exchange stocks* at the end of 1972 were 7.49 million ounces compared with 7.53 million ounces at the end of 1971. United States industrial stocks** on December 31, 1972 were reported to be about 58.0 million ounces compared with 57.1 million ounces at the end of 1971.

Outlook

Canada's mine production of silver in 1973 is forecast to rise to some 50 million ounces and is expected to range between 47 and 55 million ounces annually from 1974 to 1978.

Despite a somewhat stagnant growth rate in world consumption of silver in recent years, consumption is expected to continue to exceed primary production since mine output of silver is largely related to the production of the major base-metal ores. About 65 per cent (some 86 per cent in Canada) of the world's mine output of silver is derived as a byproduct or coproduct in the mining of such ores and, accordingly, the supply of newly mined silver continues to depend more on the production of base-metal ores than on the demand for silver.

In the near term, however, there should be no real shortage for industrial requirements since sufficient quantities of secondary silver, speculative holdings and some hoarded silver coins will continue to find their way into the market. Because of the higher price and the increasing emphasis on recycling in both the governmental and industrial sectors of the economy, greater quantities of secondary silver are expected to reach the market. Some 117.5 million ounces are expected to enter the U.S. market, possibly over the next two years, as a result of the proposed reduction in the U.S. strategic stockpile of silver announced by President Nixon in March 1973. Additional supplies may also continue to come from the U.S.S.R. and India.

The silver industry strengthened in 1972, reflecting a more buoyant United States economy. Because of the continuing upturn in the U.S. economy and

* London bullion merchant stocks of silver are not known but have been reported to total some 100 million ounces. ** Refiner, fabricator and dealer stocks.

anticipated improvement in the economies of Europe and Japan, the outlook for the silver industry is optimistic. Over the next few years the demand for silver for both industrial uses and coinage (especially commemorative coins) is expected to increase significantly. It is expected that federal legislation will be enacted in 1973 to permit the minting of silver-bearing coins by the Royal Canadian Mint to commemorate the Olympic games which will be held in Montreal, Quebec, in 1976. Such coins may require a significant quantity of silver. On March 1, 1973, the New York Handy and Harman silver price established a new record high of $2.575 an ounce when it surpassed the previous peak of $2.565 set on June 12, 1968. Since then the price has declined somewhat. Although the silver price may be somewhat stabilized in the short term by anticipated releases from the U.S. strategic stockpile, the long-term price trend should be upward. There will, however, be price fluctuations above and below the trend line and which will depend on speculative reaction to economic, monetary and political developments as they occur.

Canadian developments

Atlantic provinces. Silver production in the Atlantic provinces was somewhat higher in 1972 than in the previous year mainly because of greater byproduct output by Brunswick Mining and Smelting Corporation Limited, which operated base-metal mines near Bathurst, N.B. Significantly greater production by American Smelting and Refining Company at its zinc-lead-copper-silver mine at Buchans, Nfld., also contributed to the increase. Silver output in 1972 at the Buchan's mine was almost double that of 1971 when a 21-week labour strike interrupted operations.

Quebec. Silver output in the province, derived almost entirely from base-metal and gold ores, was substantially lower in 1972 than in 1971. Considerably reduced output by Manitou-Barvue Mines Limited, near Val-d'Or, which was shut down for most of the first half of 1972, accounted for much of the decrease. Gaspé Copper Mines, Limited, at Murdochville, was the leading mine producer with byproduct output of some 580,000 ounces.

In 1972 Copperfields Mining Corporation Limited discovered the Magusi River copper-zinc-precious metals deposit in Hebecourt Township 20 miles northwest of Noranda. It is a massive sulphide deposit containing sections of high-grade copper and/or zinc with precious metals. Teck Corporation Limited and an affiliated company, Iso Mines Limited, are participating with Copperfields in jointly exploring the project. Diamond drilling in 1972 indicated deposits of some 1.69 million short tons* grading 2.25 per cent copper, 0.4 per cent zinc, and 1.2 ounces of silver and 0.01 ounce of gold a ton, and 2.05 million tons grading 0.4 per cent copper, 5.5 per cent zinc, and 0.6 ounce of silver and 0.046 ounce of gold a ton.

Ontario. Ontario was again, by far, the leading silver-producing province with its output accounting for almost 42 per cent of Canadian mine production. The largest producer was again Ecstall Mining Limited, which recovered over 13 million ounces in lead, copper and zinc concentrates at its Kidd Creek property, the largest single mine producer of silver in Canada. In the Cobalt-Gowganda area of northern Ontario, some 2.30 million ounces were derived from silver-cobalt mines. This output was somewhat lower than in 1971 mainly because of considerably reduced production by Agnico-Eagle Mines Limited where most of the ore production was stockpiled in anticipation of higher silver prices. Late in 1972 the veteran producer in the Cobalt-Gowganda area, Siscoe Metals of Ontario Limited, finally suspended operations because of exhaustion of ore reserves. With the exception of 1945 and 1946 the mine had been in continuous operation since about 1908, although Siscoe did not become the owner of the property until 1945. For many of the more than 60 years that the mine was in production it was the largest single mine producer of silver in the Cobalt-Gowganda district.

In April 1973 it was reported that St. Joseph Explorations Limited, a wholly owned Canadian subsidiary of St. Joe Minerals Corporation of New York, had signed an agreement with Silver Shield Mines Inc. whereby St. Joseph acquired control of Silver Shield's silver-cobalt mining properties in the Cobalt-Gowganda area of northern Ontario. Apparently the agreement relates only to the mining operation and mineral deposits near Cobalt owned by Silver Shield. Press reports also indicated that the assets in question would be transferred to a newly formed company to be owned 51 per cent by St. Joseph and 49 per cent by Silver Shield.

Late in 1972 Falconbridge Copper Limited and NBU Mines Limited jointly acquired from Mattagami Lake Mines Limited open pit mining rights on two mining claims in the Sturgeon Lake district of northwestern Ontario. This makes possible the mining of the 'Boundary' orebody of the two companies' subsidiary, Sturgeon Lake Mines Limited, as a single open pit. The two claims in question contain that portion of the orebody which extends into adjoining property owned by Mattagami Lake Mines Limited. On completion of open pit mining on the two claims concerned, they will be returned to Mattagami. After completing an engineering estimate of the capital, preproduction and operating costs for mining the 'Boundary' orebody it was decided to bring it into production. Total pit-minable reserves in the 'Boundary' orebody are estimated at 2,110,000 tons after allowing for 5 per cent dilution.

*All tons are short tons of 2,000 pounds unless otherwise specified.

Table 4. Principal silver (mine) producers in Canada, 1972 and [1971]

Company and Location	Mill or Mine Capacity	Grade of Ore: Silver	Grade of Ore: Copper	Grade of Ore: Lead	Grade of Ore: Zinc	Ore Produced	Contained Silver Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Newfoundland								
American Smelting and Refining Company (Buchans Unit), Buchans	1,250 [1,250]	3.73 [3.71]	1.13 [1.08]	7.18 [6.90]	12.89 [12.39]	291,000 [173,000]	949,439 [537,638]	Extensive exploration of past several years failed to find new orebody and was curtailed. Ore reserves sufficient for 6 years based on costs and metal prices at end of 1972.
Consolidated Rambler Mines Limited, Ming and East mines, Baie Verte	1,200 [1,500]	0.346 [0.076]	1.84 [1.12]	– [–]	– [–]	386,205 [429,351]	107,314 [30,508]	Ming mine brought into full production in 1972 at 600 tpd of ore.
Nova Scotia								
Dresser Minerals, Division of Dresser Industries, Inc., Walton	– [140]	– [4.35]	– [0.36]	– [3.3]	– [0.5]	– [16,125]	– [53,730]	No base-metal mining nor milling in 1972. Mill expected to operate for a short period in 1973 to process small stockpile of ore.
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, Bathurst								
No. 12 mine[1]	6,350 [6,000]	2.82 [2.44]	0.27 [0.30]	3.62 [3.25]	9.10 [8.11]	1,513,949 [1,567,352]	2,660,453 [. .]	Total silver contained in concentrates produced at No. 12 and 6 mines in 1972, 4,797,074 ounces.

No. 6 mine[2]	3,500 [3,500]	2.10 [1.86]	0.37 [0.36]	2.04 [2.11]	5.46 [5.76]	1,743,610 [847,000]	2,136,621 [. .]	
Heath Steele Mines Limited, Newcastle	3,000 [3,000]	1.70 [2.21]	1.13 [0.97]	1.46 [2.23]	3.93 [5.29]	835,867 [972,456]	806,668 [1,068,212]	Mill expansion to begin in 1973 and scheduled increase to 4,000 tpd by 1976.
Nigadoo River Mines Limited[3], Bathurst	– [1,000]	– [3.37]	– [0.27]	– [2.53]	– [2.66]	– [322,956]	– [938,140]	Production ceased November 1971 with commencement of labour strike.
Quebec								
Campbell Chibougamau Mines Ltd., Main Mine, Cedar Bay and Henderson mines, Chibougamau	4,000 [4,000]	0.2451 [0.2717]	1.48 [1.52]	– [–]	– [–]	987,266 [1,294,285]	158,728 [227,645]	Operations suspended December 18, 1971 to March 14, 1972 due to labour strike.
Delbridge Mines Limited, Noranda	– [500]	– [2.86]	– [0.45]	– [–]	– [8.62]	– [154,172]	– [245,382]	Operations suspended September 1971.
D'Estrie Mining Company Ltd., Stratford Centre	300 [300]	1.212 [0.974]	2.70 [2.11]	0.72 [0.57]	3.28 [2.52]	109,138 [83,506]	113,970 [55,769]	Proven ore reserves August 31, 1972: 1,071,000 tons averaging 3.21% copper, 2.14% zinc, 0.67% lead and and 1.127 ounce silver a ton.
Falconbridge Copper Limited, Lake Dufault Division, Millenbach and Norbec mines, Noranda	1,500 [1,500]	1.40 [0.60]	3.16 [1.48]	– [–]	4.39 [2.02]	561,625 [509,095]	534,786 [227,143]	Winze sinking facilities installed and 507 feet completed. Of remaining 1,123 feet to be sunk, 709 feet of pilot raise was driven.
Falconbridge Copper Limited, Opemiska Division, Perry, Springer and Robitaille mines, Chapais	3,000 [3,000]	0.33 [0.31]	2.20 [2.31]	– [–]	– [–]	1,156,864 [1,074,047]	324,255 [285,254]	Robitaille orebody mined out in 1972. Work to begin in 1973 on surface installations and shaft sinking for new Cooke mine.

Table 4 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Silver	Grade of Ore: Copper	Grade of Ore: Lead	Grade of Ore: Zinc	Ore Produced	Contained Silver Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain mines, Murdochville	11,000 [11,000]	0.147 [. .]	0.91 [0.91]	– [–]	– [–]	3,939,738 [3,980,525]	578,881 [554,640]	Expansion of mill capacity to 34,000 tpd scheduled for completion in 1973.
Madeleine Mines Ltd., Ste-Anne-des-Monts	2,500 [2,500]	0.30 [. .]	1.42 [1.38]	– [–]	– [–]	729,608 [869,467]	173,729 [197,116]	Production suspended November 13, 1972 by labour strike settled February 12, 1973.
Manitou-Barvue Mines Limited, Golden Manitou mine[4], Val-d'Or	1,600 [1,600]	4.68 [4.42]	– [–]	0.33 [1.42]	1.16 [1.96]	60,234 [225,915]	226,527 [769,838]	After suspension since October 1971, mining resumed July 1972.
Mattagami Lake Mines Limited, Matagami	3,850 [3,850]	0.88 [1.07]	0.56 [0.62]	– [–]	7.4 [9.3]	1,370,167 [1,386,160]	397,365 [597,741]	Pillar ore made up 31.8% of total ore mined in 1972. Of 54 ore blocks mined, 15 have been pillars.
Noranda Mines Limited, Horne Division, Noranda	3,000 [3,000]	0.488 [0.435]	2.30 [2.24]	– [–]	– [–]	686,566 [682,618]	204,431 [187,284]	Horne mine expected to be closed down by end of 1973 or early 1974 because of exhaustion of ore reserves.
Normetal Mines Limited, Normetal	1,000 [1,000]	1.43 [1.50]	1.73 [1.76]	– [–]	5.29 [5.74]	326,475 [335,298]	299,480 [321,480]	Mine expected to cease operations by end of 1973 because of exhaustion of ore reserves.
Orchan Mines Limited, Matagami	2,000 [2,000]	1.1 [1.27]	1.05 [0.93]	– [–]	10.6 [10.66]	376,840 [409,492]	208,341 [254,222]	Regular production of ore at 12,000 tpm began January 1973, at company's nearby Garon Lake base-metal mine.

Patino Mines (Quebec) Limited, Chibougamau, (formerly The Patino Mining Corporation, Copper Rand Mines Division)	2,800 [2,800]	0.194 [0.21]	1.77 [1.94]	– [–]	– [–]	1,018,633 [992,401]	163,597 [166,370]	Jaculet mine being kept pumped out and on standby basis.
Quemont Mines Limited, Noranda	– [2,400]	– [1.03]	– [0.78]	– [–]	– [2.06]	– [332,916]	– [125,889]	Mining and milling ceased November 11, 1971 when ore exhausted.
Sullivan Mining Group Ltd., Cupra Division[3], Stratford Centre	1,500 [1,400]	0.990 [1.050]	2.24 [2.29]	0.60 [0.63]	3.97 [3.86]	117,339 [134,663]	99,485 [96,785]	Ore reserves August 31, 1972 were: 379,000 tons grading 2.37% copper, 2.37% zinc, 0.49% lead, 0.832 ounce silver and 0.011 ounce gold a ton.
Ontario								
Agnico-Eagle Mines Limited, Trout Lake No. 3 shaft mine, Cobalt district, (formerly Agnico Mines Limited)	400 [400]	.. [18.38]	– [–]	– [–]	– [–]	.. [29,960]	99,169 [529,485]	Trout Lake No. 3 shaft sunk 268 feet below previous 850-ft level and 3 new levels established.
Big Nama Creek Mines Limited, Manitouwadge	– [125]	– [1.07]	– [0.81]	– [0.06]	– [5.12]	– [41,717]	– [..]	Mining suspended September 1971 because known ore reserves depleted.
Ecstall Mining Limited (Texas Gulf, Inc.), Kidd Creek mine, Timmins	10,000 [10,000]	4.35 [4.05]	1.44 [1.38]	0.39 [0.35]	10.14 [9.74]	3,628,501 [3,673,350]	13,136,000 [12,768,177]	Preproduction development almost completed on 800 and 1,200 levels of underground mine. Underground ore handling system expected to supply 2,000 tpd of ore by end of 1973.
Falconbridge Nickel Mines Limited, Ontario mines, Sudbury district	13,600 [14,100]	.. [..]	.. [..]	– [–]	– [–]	4,152,185 [4,593,428]	.. [..]	Preparation for recovery of crown pillar at Hardy mine by open pit methods.

Table 4 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Silver	Grade of Ore: Copper	Grade of Ore: Lead	Grade of Ore: Zinc	Ore Produced	Contained Silver Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Mattabi Mines Limited, Sturgeon Lake	3,000 [–]	4.99 [–]	1.27 [–]	1.27 [–]	11.97 [–]	438,838 [–]	1,516,677 [–]	Regular production of ore began August 1972.
Noranda Mines Limited, Geco Division, Manitouwadge	5,200 [5,000]	1.93 [2.03]	2.12 [2.27]	0.15 [0.15]	4.30 [5.52]	1,815,164 [1,759,952]	2,529,862 [2,593,566]	Facilities installed to recycle tailings-pond decant as mill process water supply.
Patricia Silver Mines Limited, Nipissing-North property, Cobalt district	– [30]	– [. .]	– [. .]	– [–]	– [–]	– [9,068]	– [142,206]	Mining operations suspended in 1971.
Selco Mining Corporation Limited, South Bay Division, Uchi Lake area	500 [500]	3.2 [. .]	2.1 [2.33]	. . [. .]	12.0 [13.29]	183,000 [130,019]	485,716 [. .]	Began mining below 300 level and completed ramp from 300 to 600 level.
Siscoe Metals of Ontario Limited, Gowganda district	275 [275]	26.7 [23.9]	. . [. .]	– [–]	– [–]	29,495 [42,002]	788,695 [979,282]	Mining and milling suspended November 1972
Teck Corporation Limited, Silverfields Division, Cobalt district	270 [250]	17.5 [14.8]	0.07 [0.06]	– [–]	– [–]	79,319 [76,149]	1,343,918 [1,129,330]	Milling suspended for 7 weeks February-March 1972 for repairs and expansion in mill capacity from 225 to 270 tpd of ore.
The International Nickel Company of Canada, Limited, Sudbury, Ont. and Thompson, Man.	97,500 [95,000]	. . [. .]	. . [. .]	– [–]	– [–]	18,938,225 [21,847,000]	1,930,000[5] [1,743,000][5]	Ore production cutbacks begun in latter half of 1971 completed by spring of 1972, but in 1972 mining concentrated in areas containing higher-grade ores.

Willroy Mines Limited, Willroy and Willecho mines, Manitouwadge	1,700 [1,600]	1.41 [1.36]	1.10 [0.89]	0.14 [0.13]	3.27 [3.33]	431,067 [427,589]	454,971 [411,052]	Extensive underground exploration work and surface drilling program scheduled for 1973.
Manitoba–Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake districts	6,800 [7,500]	0.59 [0.50]	2.67 [2.80]	.. [0.2]	3.28 [3.2]	1,847,903 [1,084,000]	837,529 [417,276]	White Lake and Ghost Lake mines brought into production in 1972. Flexar mine ceased operations in 1972 because ore reserves depleted. Decision not yet made to develop for production the Wim, Reed Lake, Rail Lake and Hudvam base-metal deposits.
British Columbia								
Bethlehem Copper Corporation Ltd., Highland Valley	16,300 [15,000]	.. [..]	0.540 [0.52]	– [–]	– [–]	5,964,696 [5,625,999]	162,000 [..]	By end of 1972 ore production derived fully from Huestis open pit.
Bradina Joint Venture, Houston	600 [–]	5.31 [–]	0.42 [–]	0.89 [–]	4.45 [–]	111,024 [–]	329,378 [–]	Mill tune-up began March 9, 1972.
Brenda Mines Ltd., Peachland	24,000 [24,000]	.. [..]	0.208 [0.212]	– [–]	– [–]	9,503,190 [8,987,210]	302,600 [300,211]	Copper concentrate regrind circuit installed in 1972 to raise grade of concentrate.
Cominco Ltd., Sullivan mine, Kimberley	10,000 [10,000]	.. [..]	.. [..]	.. [..]	.. [..]	1,925,099 [2,005,301]	3,026,084 [3,666,522]	Cominco's total output of refined silver from all sources 6,948,882 ounces in 1972.
Bluebell mine, Riondel	– [750]	– [..]	– [..]	– [..]	– [..]	– [256,797]	– [..]	Operations suspended December 1971 because ore reserves depleted.

Table 4 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Silver	Grade of Ore: Copper	Grade of Ore: Lead	Grade of Ore: Zinc	Ore Produced	Contained Silver Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Copperline Mines Ltd., Ruth-Vermont mine, Golden	– [600]	– [. .]	– [. .]	– [. .]	- [. .]	– [58,593]	– [. .]	Mill tune-up operations begun September 1970, suspended June 1971.
The Granby Mining Company Limited, Granisle mine, Babine Lake	14,000 [6,500]	. . [. .]	0.55 [0.56]	– [–]	– [–]	2,537,138 [2,288,952]	. . [102,020]	Mill capacity increased from 6,500 to 14,000 tpd of ore.
The Granby Mining Company Limited, Phoenix Copper Division, Greenwood	2,600 [2,400]	0.258 [0.236]	0.677 [0.79]	– [–]	– [–]	873,982 [902,325]	99,119 [134,298]	Mill capacity increased from 2,400 to 2,600 tpd of ore.
Granduc Operating Company, Stewart	7,500 [7,500]	. . [. .]	1.35 [1.31]	– [–]	– [–]	2,089,865 [1,498,854]	476,962 [414,473]	Although operating and manpower problems continued to hamper operations, in December 1972 mine and mill production finally reached planned level of 7,000 tpd of ore.
Kam-Kotia Mines Limited, Silmonac mine, Slocan district	150 [150]	16.44 [17.99]	. . [. .]	5.81 [6.39]	6.62 [6.60]	27,429 [39,154]	425,065 [681,407]	At end of 1972 proven ore reserves almost exhausted but operators exploring large segment of lode considered to have good potential.
Lornex Mining Corporation Ltd., Highland Valley	38,000 [–]	0.03 [–]	0.427 [–]	– [–]	– [–]	5,468,794 [–]	169,200 [–]	Production began October 1, 1972

Reeves MacDonald Mines Limited, Remac	1,000 [1,000] (treated at central mill)							
Reeves mine		– [. .]	– [. .]	– [1.41]	– [4.50]	– [25,296]	– [7,207]	Operations curtailed July 1971 due to depletion of known ore reserves.
Annex mine		1.91 [2.51]	. . [. .]	0.59 [0.89]	7.07 [8.63]	180,188 [166,089]	284,822 [358,428]	Drift extended from 240-ft level of Reeves mine west under Pend d'Oreille River to develop mineralized zone opened up at east end of Annex mine at 1,000-ft horizon.
Teck Corporation Limited[6], Beaverdell mine, Beaverdell	115 [115]	18.23 [17.52]	0.003 [. .]	0.72 [0.70]	0.76 [0.80]	37,091 [36,404]	676,046 [637,797]	New level being driven 3,000 feet to develop ore indicated by diamond drilling.
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Island	33,000 [33,000]	. . [. .]	0.53 [0.51]	– [–]	– [–]	7,980,429 [1,040,608]	207,500 [21,600]	Some modifications to milling plant to be completed in 1973.
Wesfrob Mines Limited, Tasu Harbour, Queen Charlotte Islands	8,000 [8,000]	. . [. .]	0.47 [0.60]	. . [. .]	. . [. .]	595,505[7] [996,471][7]	72,808 [226,366]	Silver contained in copper concentrate produced as byproduct of iron ore mining and beneficiation.
Western Mines Limited, Buttle Lake, Vancouver Island	1,100 [1,000]	. . [1.6]	1.85 [2.00]	0.68 [0.70]	6.02 [6.90]	374,022 [386,541]	571,838 [479,923]	Plans to drive Price Tunnel through Myra Mountain to explore eastward extension of ore-bearing alteration zone.
Northwest Territories								
Echo Bay Mines Ltd., Port Radium	100 [100]	67.0 [68.9]	1.14 [0.9]	– [–]	– [–]	37,290 [36,820]	2,440,000 [2,536,172]	Continued exploration in Great Bear Lake area.

Table 4 (concl'd)

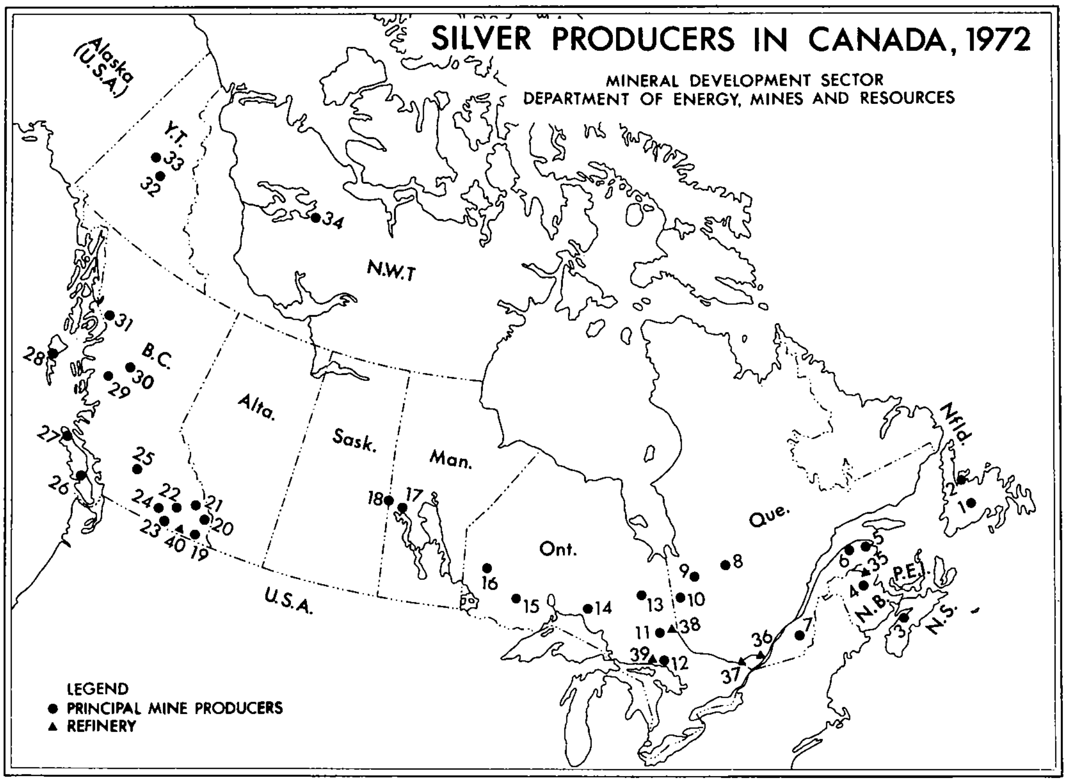
Company and Location	Mill or Mine Capacity	Grade of Ore				Ore Produced	Contained Silver Produced	Remarks
		Silver	Copper	Lead	Zinc			
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Terra Mining and Exploration Limited, Camsell River area	175 [300]	81.63 [33.7]	0.38 [0.87]	– [–]	– [–]	24,723 [48,715]	1,921,338 [1,193,086]	Mining resumed May 5, 1972 after suspension since December 1971 due to lack of adequate financing.
Yukon Territory								
Anvil Mining Corporation Limited, Faro	8,000 [7,700]	. . [. .]	. . [. .]	4.63 [4.92]	6.22 [6.74]	2,905,530 [2,673,000]	2,857,900 [2,934,894]	Increasing mill capacity to 10,000 tpd of ore by 1974 to permit economic milling of lower-grade ores.
United Keno Hill Mines Limited, Hector-Calumet, Elsa, Husky, and No Cash mines, and development ore from Dixie and Townsite adits, Elsa	550 [550]	34.23 [30.57]	. . [. .]	4.61 [5.17]	3.19 [5.19]	80,646 [94,754]	2,634,176 [3,007,463]	Hector-Calumet mine finally closed due to depletion of known ore reserves. Intensive exploration and development programs continued during 1972.

Source: Company reports.
[1]Grade and production for 1971 represent ore *produced* at No. 12 mine only. In 1971, No. 12 mill processed an additional 625,000 tons of ore from No. 6 mine. [2]Grade and production for 1971 represent ore *produced* at No. 6 mine only. [3]Production for 1971 is for fiscal year ended August 31. [4]Grade and production do not include 272,712 tons of copper ore custom milled in separate circuit. [5]Silver delivered to markets. [6]Grade and production for 1972 are for fiscal year ended September 30, 1972. [7]Ore produced in No. 3 zone only.
– Nil; . . Not available.

Table 5. Prospective[1] silver producing mines in Canada

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Average Grade of Ore: Lead	Zinc	Copper	Silver	Remarks
		(tons ore/day)	(tons)	(%)	(%)	(%)	(oz/ton)	
New Brunswick								
Heath Steele Mines Limited, Little River mine, Newcastle	1975	. .	. .	. .	. .	. .	. .	Ore to be milled at company's existing mill.
Quebec								
Falconbridge Copper Limited, Opemiska Division, Cooke mine, Chapais	. .	300	550,000	–	–	1.46	. .	Ore to be milled at company's existing mill.
Ontario								
Sturgeon Lake Mines Limited, Sturgeon Lake area	1975	1,200	2,110,000	1.47	10.64	2.98	6.14	Ore to be mined by open pit methods. Company is owned 67% by Falconbridge Copper Limited, 33% by NBU Mines Limited.
Manitoba								
Hudson Bay Mining and Smelting Co., Limited, Centennial mine, Flin Flon district	1975	. .	1,400,000	. .	2.6	2.06	. .	Ore to be milled at company's central mill at Flin Flon.

[1]Those mines which have announced production plans.
– Nil; . . Not available.



Principal mine producers

(numbers refer to numbers on the map)

1. American Smelting and Refining Company (Buchans Unit)
2. Consolidated Rambler Mines Limited
3. Dresser Minerals, Division of Dresser Industries, Inc.
4. Brunswick Mining and Smelting Corporation Limited (No. 12 and 6 mines)
   Heath Steel Mines Limited
5. Gaspé Copper Mines, Limited
6. Madeleine Mines Ltd.
7. D'Estrie Mining Company Ltd.
   Sullivan Mining Group Ltd., Cupra Division
8. Campbell Chibougamau Mines Ltd.
   Falcnobridge Copper Limited, Opemiska Division
   Patino Mines (Quebec) Limited
9. Mattagami Lake Mines Limited
   Orchan Mines Limited
10. Falconbridge Copper Limited, Lake Dufault Division
    Manitou-Barvue Mines Limited
    Noranda Mines Limited (Horne Division)
    Normetal Mines Limited
11. Agnico-Eagle Mines Limited
    Siscoe Metals of Ontario Limited
    Teck Corporation Limited, Silverfields Division
12. The International Nickel Company of Canada, Limited
    Falconbridge Nickel Mines Limited
13. Ecstall Mining Limited
14. Noranda Mines Limited, Geco Division
    Willroy Mines Limited
15. Mattabi Mines Limited
16. Selco Mining Corporation Limited, South Bay Division
17. Hudson Bay Mining and Smelting Co., Limited (Anderson Lake, Chisel Lake, Dickstone, Osborne Lake and Stall Lake mines)
18. Hudson Bay Mining and Smelting Co., Limited (Flexar, Flin Flon, Ghost Lake, Schist Lake and White Lake mines)
19. Reves MacDonald Mines Limited
20. Cominco Ltd. (Sulivan mine)
21. Kam-Kotia Mines Limited (Silmonac mine)
22. Brenda Mines Ltd.
23. The Granby Mining Company Limited, Phoenix Copper Division
24. Teck Corporation Limited (Beaverdell mine)
25. Bethlehem Copper Corporation Ltd.
26. Western Mines Limited

27. Utah Mines Ltd.
28. Wesfrob Mines Limited
29. Nadina Explorations Limited (Bradina Joint Venture property)
30. The Granby Mining Company Limited, Granisle mine
31. Granduc Operating Company
32. Anvil Mining Corporation Limited
33. United Keno Hill Mines Limited
34. Echo Bay Mines Ltd.
    Terra Mining and Exploration Limited

Refineries

35. Brunswick Mining and Smelting Corporation Limited, Smelting Division
36. Canadian Copper Refiners Limited
37. Royal Canadian Mint
38. Kam-Kotia Mines Limited, Refinery Division
39. The International Nickel Company of Canada, Limited
40. Cominco Ltd.

In February 1972 Mattagami Lake Mines Limited discovered another orebody on its wholly owned Claim Group No. 23 in the Sturgeon Lake area adjoining Abitibi Block No. 7 on the east. Known as the Creek zone it lies midway between the 'Boundary' orebody of Sturgeon Lake Mines Limited and Mattagami's Lyon Lake ore zone discovered in October 1971. Tonnages and grades in these two orebodies at December 31, 1972, were as follows:

	Lyon Lake zone	Creek zone
Ore reserves (tons)	1,097,000	908,000
Average grade of ore		
Gold (oz/ton)	0.007	0.019
Silver (oz/ton)	2.96	4.71
Zinc (%)	6.81	8.84
Copper (%)	1.03	1.66
Lead (%)	0.59	0.76

Manitoba–Saskatchewan. In Manitoba and Saskatchewan most of the silver continued to come from ten base-metal mines operated by Hudson Bay Mining and Smelting Co., Limited near Flin Flon and Snow Lake, Manitoba.

British Columbia. Base-metal ores continued to be the main source of British Columbia's mine output of silver. Cominco Ltd., the largest silver producer in the province, derived its output from the lead-zinc-silver ores of its Sullivan mine in southeastern British Columbia, and from purchased ores and concentrates.

Mill tune-up operations began in March 1972 at the silver-zinc-copper-lead property of Nadina Explorations Limited 28 miles south of Houston. The mill produces a copper concentrate and a bulk zinc-lead concentrate. The property is operated by Bralorne Resources Limited under the name of Bradina Joint Venture. Following repayment of development funds advanced by Bralorne and Pacific Petroleums, Ltd., profits will be shared 50 per cent by Nadina, 25 per cent by Bralorne and 25 per cent by Pacific Petroleums.

Dolly Varden Mines Ltd. continued exploration work at its silver-zinc-lead property near Alice Arm in northwestern British Columbia. A diamond drilling program and a production feasibility study were carried out in the summer of 1972. The possibility of installing an underground mill is being evaluated. Ore reserves are reported to be 1.7 million tons grading 9.51 ounces of silver a ton, 0.80 per cent zinc and 0.51 per cent lead.

Northwest Territories. Sharply increased silver production in 1972 in the Northwest Territories resulted from much higher output by Terra Mining and Exploration Limited. Terra and Echo Bay Mines Ltd., which operate silver-copper properties near Port Radium on the east shore of Great Bear Lake, were again the principal silver producers in the Northwest Territories.

In the second half of 1972 Texas Gulf, Inc. signed an agreement with Mineral Resources International Limited (MRI) whereby MRI was granted an option on Texas Gulf's zinc-lead-silver property on Baffin Island. If the property is placed in production Texas Gulf will receive 35 per cent of the net profits after the recovery of production financing by MRI and exploration and development expenditures incurred by both companies. A production feasibility study was expected to be completed by the end of May 1973. Financing for production is estimated at over $30 million for a 1,500- to 2,000-ton-a-day operation. Previous work on the property indicated a deposit containing 7,000,000 tons averaging 14 per cent zinc, 2 per cent lead and 2 ounces of silver a ton.

Further diamond drilling was done on the zinc-lead-silver-copper prospect which Cominco Ltd. has optioned from Bathurst Norsemines Ltd. The property is on the Hackett River at Bathurst Inlet on the Arctic coast, some 330 air-miles northeast of Yellowknife. Diamond drilling results have indicated the property's 'A' zone contains a mineral deposit of 5,300 tons per vertical foot averaging 8.5 per cent zinc, 1.4 per cent lead, 0.25 per cent copper, 7.0 ounces of silver and 0.05 ounce of gold a ton.

Yukon Territory. A slight decrease in silver production in 1972 in the Yukon Territory resulted from lower output at the zinc-lead-silver properties of Anvil Mining Corporation Limited and United Keno Hill Mines Limited.

A possible new silver-lead district was discovered in 1972 by Dynasty Explorations Limited and its associate, Atlas Explorations Limited, in the Hess Mountains area some 108 miles north of Ross River. It is the Plata Silver prospect which is 100 miles to the east of the property of United Keno Hill Mines Limited. Mineralization consists of silver-gold-lead-zinc veins, with some high values in silver having been indicated by diamond drilling. Dynasty is financing the project and holds an 80 per cent interest in the venture, with Atlas having a 20 per cent carried interest. A program of extensive bulldozer trenching, surveys and prospecting has been planned for the project and an airstrip and access road were to be constructed prior to the 1973 spring breakup.

No further work was reported to have been done on the silver-lead-zinc 'Tom' claims of Hudson Bay Mining and Smelting Co., Limited on the Canol Road near the Yukon–Northwest Territories border. The deposit contains an estimated 8,645,000 tons averaging 8.4 per cent zinc, 8.1 per cent lead and 2.75 ounces of silver a ton.

Uses

Although the number of industrial applications for silver has increased, significant quantities of the metal are still used in the manufacture of coinage, especially commemorative coins. This is because it strongly resists corrosion, has good alloying properties, an attractive appearance and intrinsic value. According to Handy and Harman, noncommunist world consumption of silver for coinage dropped from a high of 381.1 million ounces in 1965 to 27.3 million in 1971 but then rose to an estimated 40.5 million in 1972. Silver is used extensively in jewelry, sterling and plated silverware, and as a decorative material, for the same properties that made it popular in the past as a coinage metal as well as for its high malleability, ductility and ability to take a fine finish. Phillips Petroleum Company has recently developed a very promising anti-tarnish compound called Meos which permits treated silver to remain untarnished 20 to 60 times longer than untreated silver. The photographic industry, in which the use of silver is based on the light sensitivity and ease of reduction of certain silver compounds, is the metal's greatest single user. Silver halide is the light-sensitive chemical coating on film that makes photography possible. In 1972 photographic materials accounted for about 26.1[1] per cent of total industrial consumption of silver in the United States. The only significant development that could bring about a real change in the substantial use and growth of silver in this major outlet would be the discovery of a suitable and economic substitute. In spite of the vast amount of research that has been done in this field for several years, and the repeated rumours and announcements of imminent replacement, a suitable silverless photographic process is not yet in prospect. Even if a satisfactory substitute should be found, it could take some years to effect the transition.

[1] Based on figures contained in Table 6 herein.

Table 6. United States consumption of silver by end-use, 1971-72

	1971	1972^p
	(ounces)	
Electroplated ware	10,909,206	12,565,928
Sterling ware	22,729,197	27,162,656
Jewelry	3,447,254	4,870,595
Photographic materials	36,072,350	38,251,064
Dental and medical supplies	1,484,435	1,984,340
Mirrors	1,111,409	1,225,534
Brazing alloys and solders	12,085,020	11,951,011
Electrical and electronic products:		
batteries	5,631,050	5,593,537
contacts and conductors	27,953,893	32,941,351
Bearings	355,331	345,511
Catalysts	1,730,161	3,429,719
Miscellaneous[1]	5,636,360	6,379,397
Total net industrial consumption	129,145,666	146,700,643
Coinage	2,473,900	2,284,360
Total consumption	131,619,566	148,985,003

Source: U.S. Bureau of Mines, Mineral Industry Surveys, Gold and Silver in December 1972.
[1]Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc.
^{p}Preliminary.

Substantially greater quantities are being used in the electrical and electronics industries because of the increasing demand for silver contacts, conductors, and other silver-bearing components. These applications include extensive quantities of silver used in the component parts of complex electronics systems to assure maximum conductivity and reliability in guidance systems for spacecraft. In 1972 electrical and electronic products accounted for about 26.3[1] per cent of total industrial consumption of silver in the United States. Silver is an important constituent of many brazing and soldering alloys, because of the low melting point of silver-copper and silver-copper-zinc alloys, their resistance to corrosion, high tensile strength, and ability to join together almost all nonferrous metals and alloys as well as iron and silver. These solders and brazing alloys are widely used in the manufacture of air conditioning and refrigeration equipment, electrical appliances and automotive parts.

Silver-zinc and silver-cadmium batteries are increasingly used in portable equipment where good output, long life and rechargeability are required. These batteries are also used in jet aircraft, missiles, satellites and space capsules where weight and dependability are of prime importance. High-energy silver-zinc batteries played a vital part in the historic Apollo flights to the moon, servicing both the command and lunar excursion modules. Silver-zinc batteries powered TV transmissions from Apollo 17's Lunar Rover. They also provide high-intensity lanterns and flashlights for plant protection and security officers. A single silver-zinc battery in a nuclear submarine may use as much as 168,000 ounces of silver.

As a catalyst, silver is used to control the oxidation of methanol to formaldehyde, and ethylene to ethylene oxide, all of which is essential to the production of plastics, antifreeze and polyester products. Silver catalysts are also used in the manufacture of carpets and permanent-press synthetic fabrics. Another growing industrial use is the almost invisible silver threads embedded in the glass of rear car windows (backlites), and which are connected to the vehicle's battery, to serve as heaters for deicing and defogging the windows. A low-cost, highly effective silver nitrate cream has been developed for the treatment of severe burns. Silver powder, 99.999 per cent pure, in the form of round beads has applications in powder metallurgy, electronic circuits, and in line silver brazing. Meteorological applications involving the use of silver iodide for cloud seeding to produce rain promise to become an important outlet for silver as many countries make great efforts to regulate the weather. Other promising new outlets for the metal are as fungicides and bactericides because of the increasing attention being paid to the ecology and environment. Research is being done pertaining to the use of silver in compounds for the improved treatment of swimming pool water. Tests indicate that the addition of small amounts of silver can significantly reduce the quantities of other chemicals used in swimming pools for purification purposes. Recycling water with minute quantities of silver chloride also helps eliminate unpleasant odors and tastes in the water and acts as a

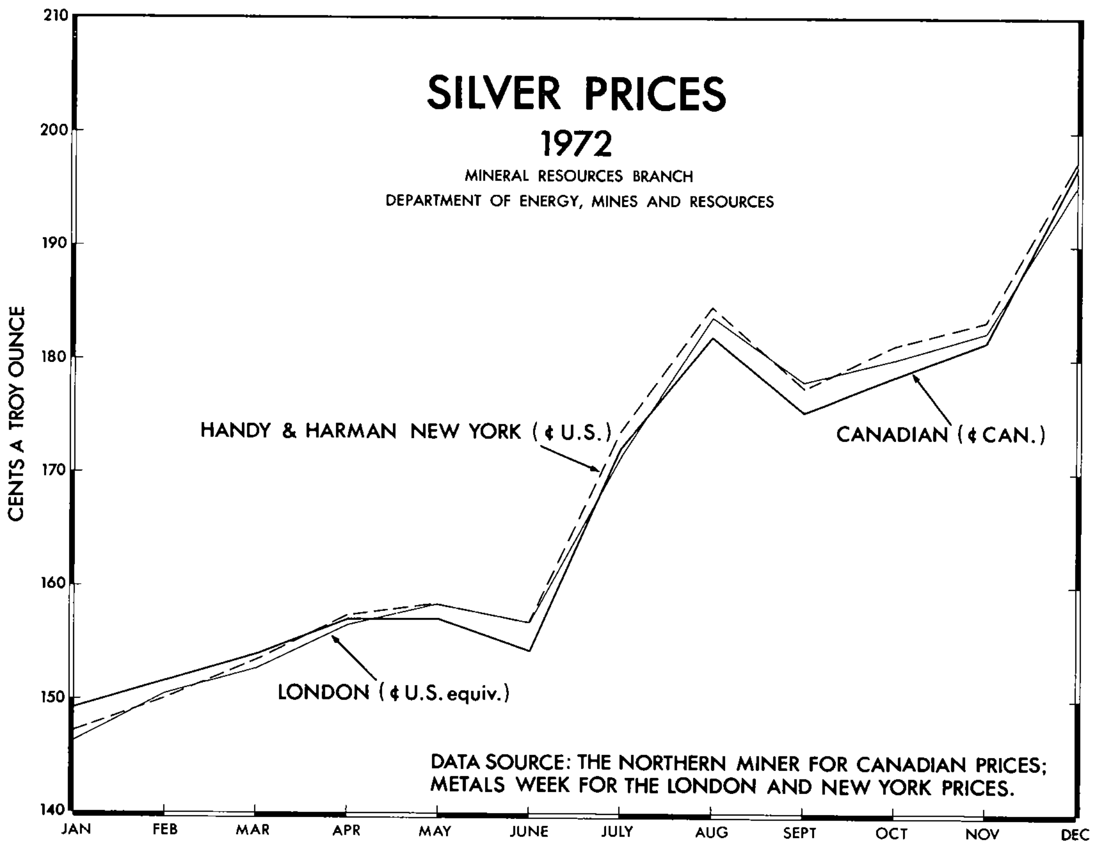


Table 7. Annual average silver prices: Canada, United States and United Kingdom, 1963-72

	Canada	United States, Handy & Harman, New York	United Kingdom London	United Kingdom London
	($ Can.)	($ U.S.)	(pence)	($ U.S. equiv.)[2]
		(per ounce)		
1963	1.385	1.279	110.115	1.285
1964	1.400	1.293	111.920	1.290
1965	1.399	1.293	111.583	1.300
1966	1.398	1.293	111.815	1.301
1967	1.720	1.550	141.977	1.626
1968	2.306	2.145	219.529	2.189
1969	1.928	1.791	180.774	1.800
1970	1.849	1.771	177.068	1.768
1971	1.561	1.546	63.086[1]	1.542
1972	1.671[p]	1.685	67.403[1]	1.686

Source: Canadian prices are those quoted by Cominco Ltd. United States and United Kingdom prices are those quoted by *Metals Week*.
[1]1971 and 1972 prices are expressed in new British pence, following British conversion to decimal currency, February 11, 1971, at the rate of 100 pence per pound sterling. Previous rate was 240 pence per pound. [2]Prices have been converted at the yearly average exchange rates quoted by *Metals Week*.
[p]Preliminary.

bactericide. Silver chloride, which has recently become available in the form of a fine-sized free-flowing powder, was specially developed for use in the treatment of water to remove slime, algae and bacteria as well as in industrial and laboratory applications.

Prices

The New York Handy and Harman silver price displayed a somewhat erratic but rising trend throughout 1972. For the first time since 1967, this silver price was higher at the end of the year than it was at the beginning. On January 3, 1972 the price was $1.387 an ounce which was the low for the year. A high of $2.048 was reached on December 26 and at year-end the price was $2.042. In 1972 the London silver price ranged between a low of 53.80 pence an ounce, equivalent to $1.373 (U.S.) on January 3 and a high of 86.60 pence, equivalent to $2.033 (U.S.) on December 29.

In 1972, the Canadian silver price closely followed its United States counterpart with the essential difference being the exchange rate. It fluctuated between a low of $1.418 an ounce on January 4 and a high of $2.033 on December 22. Average for the year was $1.671.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
32900-1	Ores of metals, nop	free	free	free
35800-1	Anodes of silver	free	free	10
35900-1	Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings	free	free	free
35905-1	Scrap silver and metal alloy scrap containing silver (expires Oct. 31, 1975)	free	free	25
36100-1	Silver leaf	12½	20	30
36200-1	Articles consisting wholly or in part of sterling or other silverware, nop; manufactures of silver, nop	17½	22½	45

United States

Item No.		
601.39	Precious metal ores, silver content	free
605.20	Silver bullion, silver ore and silver precipitates	free
605.65	Rolled silver, effective Jan. 1, 1972	10.5%
605.70	Precious metal sweepings and other precious metal waste and scrap, silver content	free

Item No.		
	Silver (including platinum-plated or gold-plated silver, but not rolled silver), unwrought or semi-manufactured, effective Jan. 1, 1972:	
605.46	platinum-plated	16%
605.47	gold-plated	25%
605.48	other unwrought silver	10.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.
nop Not otherwise provided for.

Sodium Sulphate

W.E. KOEPKE

Sodium sulphate (Na_2SO_4), commonly known as 'salt cake', is one of the key raw materials used in the manufacture of pulp and paper by the 'kraft' process. It can be produced from natural deposits and brines in alkaline lakes that occur in areas of little or no drainage and dry climates, from subsurface deposits and brines, or as a byproduct from chemical processes such as the reaction of sodium chloride with sulphuric acid to make hydrochloric acid. Canada's sodium sulphate industry is based on natural brines and deposits in many alkaline lakes in the southern prairies of Saskatchewan and Alberta; throughout most of 1972, seven plants were in operation and an eighth was closed. Small quantities of byproduct salt cake are recovered at a viscose-rayon plant in Ontario, at a strontium sulphate-carbonate operation in Nova Scotia, and beginning in 1973, it will be recovered from a pulp and paper mill in Ontario.

Elsewhere in North America, naturally occurring sodium sulphate is produced in California, Texas and Wyoming and the byproduct type is produced in the eastern states.

Production and development in Canada

Production (shipments) of sodium sulphate in Canada amounted to 503,000 tons valued at $6.1 million in 1972. The figures are preliminary and exclude about 15,000 tons of byproduct salt cake recovered at a viscose-rayon plant in Ontario and an estimated 20,000 tons from a strontium sulphate-carbonate operation in Nova Scotia.

The tonnage shipped in 1972 was up 4 per cent from the previous year but the value was down 13 per cent. Sodium sulphate prices were especially weak in late 1971 and early 1972 but began to strengthen towards the end of the year as demand from the pulp and paper industry and detergent manufacturers rose. The sodium sulphate industry has suffered from excess capacity during the past 3 to 4 years but the prospects for 1973 are much brighter.

Deposits. Apart from the lakes in Saskatchewan and Alberta, sodium sulphate has also been found associated with magnesium sulphate in British Columbia and with calcium sulphate in New Brunswick. The New Brunswick deposits are deeply buried and occur as glauberite, the anhydrous double sulphate of sodium and calcium.

The sodium sulphate deposits in Saskatchewan and the bordering areas of Alberta have formed in shallow undrained lakes and ponds where runoff waters carry in dissolved sulphate from the surrounding soils. Through the years, high rates of summer evaporation have concentrated the brine and cooler fall temperatures have caused sodium sulphate to crystallize out as mirabilite ($Na_2SO_4-10H_2O$). The cycle has been repeated year after year thereby accumulating thick deposits of hydrous sodium sulphate, commonly known as Glauber's salt. Occasionally some of the sodium sulphate formed is of the anhydrous variety known as thenardite (Na_2SO_4).

Some lakes have not accumulated thick beds because the crystals of sodium sulphate that are deposited during the fall and winter are redissolved each spring, to reform a brine rich in sodium sulphate. These same lakes commonly contain a high concentration of magnesium sulphate, a mineral that may prove valuable in the future.

Reserves in Saskatchewan have been estimated at 100 million tons of anhydrous sodium sulphate, of which about one half is considered economically recoverable with current technology. Ten deposits in Saskatchewan each contain reserves ranging from 2 million to as much as 9 million tons. One deposit in Alberta contains 3 million tons of Na_2SO_4.

Recovery and processing. For most Saskatchewan producers, weather is equally important for the recovery of sodium sulphate and for its deposition. A supply of fresh water is also essential.

Sodium sulphate recovery generally begins by pumping concentrated lake brines into reservoirs during the summer. Pumping takes place when the brine is at the highest concentration. To supplement the brining system, one producer uses a floating dredge to excavate crystals from the lake bed and pumps a slurry directly to the processing plant.

The recovery cycle in the reservoir is completed when cool fall weather causes precipitation of hydrous sodium sulphate; excess fluid with impurities is drained or pumped back to the lake. The crystal bed, normally 2 to 4 feet deep, is then excavated by scrapers, shovels or draglines and moved to a stockpile. Stockpiling is done in the winter and provides sufficient feed to operate a processing plant throughout the year.

Processing consists essentially of the dehydration of the natural crystal (Glauber's salt contains 55.9 per

Table 1. Canada, sodium sulphate production and trade, 1971-72

	1971		1972[p]	
	(short tons)	($)	(short tons)	($)
Production				
Shipments	481,919	7,064,250	503,000	6,139,000
Imports				
Total crude salt cake and Glauber's salt				
United States	7,454	150,000	18,195	270,000
Britain	4,059	94,000	5,024	91,000
Belgium and Luxembourg	4,578	87,000	3,741	79,000
Other countries	5,208	86,000	–	–
Total	21,299	417,000	26,960	440,000
Exports				
Crude sodium sulphate				
United States	112,163	2,198,000	131,152	2,411,000
Jamaica	–	–	5	1,000
Trinidad-Tobago	–	–	5	. . .
Other countries (Mozambique)	10,360	101,000	–	–
Total	122,523	2,299,000	131,162	2,412,000

Source: Statistics Canada.
[p]Preliminary; – Nil; . . . Less than one thousand dollars.

cent H_2O by weight) and drying. Processing equipment includes submerged combustion units, evaporators, classifiers, centrifuges, rotary kiln dryers, screens and crushers. The end-product, a powdery white substance commonly known as salt cake, contains a minimum of 97 per cent Na_2SO_4 and can reach as much as 99.77 per cent. Uniform grain size and free flow are important in material handling and use.

The Alberta-based producer uses a solution recovery system rather than seasonal harvesting. The raw Glauber's salt is recovered from the lake bed by solution methods, which apparently has proven very successful during both summer and winter. The brine is then subjected to an evaporation and crystallization process to recover the sodium sulphate.

In July 1972 Saskatchewan Minerals suspended production at Bishopric, Saskatchewan, the smallest and oldest of the firm's three plants. A stockpile of raw sodium sulphate remains at the plant site and pumping and harvesting is likely to continue for a few years pending improved marketing conditions. Also in 1972, Saskatchewan Minerals began converting the Ingebrigt operation from the conventional pumping, harvesting and processing to solution-extraction; the changeover was scheduled for June 1973 when the raw stockpile was depleted.

By- and coproduct recovery. Courtaulds (Canada) Limited produced about 15,000 tons of byproduct salt cake in 1972 from the operation of a viscose-rayon plant at Cornwall, Ontario.

In April 1971 Kaiser Strontium Products Limited, a subsidiary of Kaiser Aluminum & Chemical Canada

Table 2. Canada, sodium sulphate production, trade and consumption, 1963-72

	Production[1]	Imports[2]	Exports	Consumption
	(short tons)			
1963	256,914	14,497	65,348	238,321
1964	333,263	30,833	107,318	244,592
1965	345,469	29,347	116,345	275,620
1966	405,314	31,261	101,417	336,346
1967	428,316	27,621	123,833	347,140
1968	459,669	25,018	108,984	391,953
1969	518,299	29,609	120,414	437,055
1970	490,547	29,155	119,888	406,812[r]
1971	481,919	21,299	122,523	383,880[e]
1972[p]	503,000	26,960	131,162	410,000[e]

Source: Statistics Canada.
[1]Producers' shipments of crude sodium sulphate.
[2]Includes Glauber's salt and crude salt cake.
[p]Preliminary; [r]Revised; [e]Estimate.

Table 3. Canada, natural sodium sulphate plants, 1972

	Plant Location	Source Lake	Annual Capacity
			(st)
Alberta			
Alberta Sulphate Limited	Metiskow	Horseshoe	100,000
Saskatchewan			
Francana Minerals Ltd.	Cabri	Snakehole	100,000
Francana Minerals Ltd.	Alsask[1]	Alsask	50,000
Midwest Chemicals Limited	Palo	Whiteshore	120,000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	100,000
Saskatchewan Minerals	Chaplin	Chaplin	150,000
Saskatchewan Minerals	Bishopric[2]	Frederick	40,000
Saskatchewan Minerals	Fox Valley	Ingebrigt	150,000
Sybouts Sodium Sulphate Co., Ltd.	Gladmar	East Coteau	50,000
Total			860,000

[1]Inactive. [2]Processing suspended in July 1972.

Limited, began recovering coproduct salt cake at Point Edward, Nova Scotia. In the production process, natural strontium sulphate (celestite) mined at nearby Loch Lomond by Kaiser Celestite Mining Limited is combined with imported, natural sodium carbonate to yield strontium carbonate and sodium sulphate. The plant is designed to produce 100 tons of each compound daily.

Beginning in June 1973 Ontario Paper Company Limited is expected to bring on stream an 80-ton-a-day byproduct salt cake recovery unit at its paper mill in Thorold, Ontario. The product is expected to contain about 70 per cent sodium sulphate and about 30 per cent sodium carbonate, which should prove quite satisfactory for usage at some pulp and paper mills.

Consumption and trade

The main use for sodium sulphate is as a raw material in the production of pulp and paper by the 'kraft' process. The kraft process yields a pulp with a very long fibre that allows manufacture of stronger paper than with other pulps and the process also makes it easier to control pollution at pulp mills. Consumption of sodium sulphate in the pulp and paper industry in Canada has increased from 154,000 tons in 1960 to an estimated 370,000 tons in 1972.

During the 1960's, the pulp and paper industry accounted for about 94 per cent of the sodium sulphate consumed in Canada and about 70 per cent in the United States. During the past year or so, there has been a sharp rise in sodium sulphate consumption in glass manufacture and the detergent industry. In fact, preliminary indications reveal that the use of sulphate in detergent preparation in North America could double in 1973. Some of the increased usage of sulphate in detergents is attributed to the banning of phosphatic detergents.

Sodium sulphate is also consumed in mineral-feed supplements, medicinals and other chemical products, and in base-metal smelting.

As indicated in Table 2, Canada's imports of sodium sulphate in 1972 were approximately equal to the past five-year average but exports climbed to an all-time high of 131,162 tons. Virtually all exports in 1972 were to the United States whereas in each of the three preceding years, upwards of 10,000 tons went to countries in Africa and Oceania.

Table 4. Canada, available data on sodium sulphate consumption, 1970-72

	1970	1971	1972^e
	(short tons)		
Pulp and paper	381,741^r	350,000^e	370,000
Glass and glass wool	6,268	6,779	7,000
Soaps	9,343	13,352	18,000
Other products[1]	9,460	13,749	15,000
Total	406,812^r	383,880	410,000

Source: Statistics Canada, breakdown by Mineral Resources Branch.
[1]Colours, pigments, foundries, feed supplements and other minor uses.
^{e}Estimated; ^{r}Revised.

Outlook

Although there has been a significant rise in the use of sodium sulphate in the detergent industry, demand for Canadian sulphate largely hinges upon the needs of the pulp and paper industry. During the past two or three years, the pulp and paper industry has suffered from excess capacity and it has also been under pressure to give greater consideration to pollution abatement. There has been a turn-around situation in the pulp and paper industry and prices have been on the rise since the autumn of 1972. Stronger demand for kraft paper has been reflected in the usage of sodium sulphate during the early months of 1973 thereby further strengthening sulphate prices.

Rising demand for sulphate for the manufacture of pulp and paper, detergents and glass should result in a favourable marketing situation for the producers of natural sodium sulphate in western Canada in 1973, as well as an outlet for the additional quantities of by- and coproduct salt cake from plants in eastern Canada.

Prices

Posted prices in Canada at the end of 1972 were identical to a year prior, but as indicated in Table 1, realized prices were substantially below posted as well as 1971 levels. Sodium sulphate was reportedly being sold as low as $11.50 a ton fob plant, Saskatchewan, early in 1972; by year-end, prices had firmed to $13 to $15 a ton.

Canadian prices of sodium sulphate, as quoted by Canadian Chemical Processing, Buyers Guide, December 1972

	(Can. $ per short ton)
Sodium sulphate (salt cake)	
Bulk, carlots, fob works	16.50
Detergent-grade bulk, fob works	20.50

United States prices according to Oil, Paint and Drug Reporter, December 27, 1972

	(U.S. $ per short ton)
Salt cake, 100% Na_2SO_4 basis, fob works	28
Salt cake, domestic, West, bulk, carlots, fob producing point	18.50
Sodium sulphate, detergent, rayon-grade, carlots, fob works, bulk	
East	40 – 43
West	33 – 34

Tariffs

Canada

Item No.

21000-1 Natural sodium sulphate: British Preferential 10%; Most Favoured Nation 15%; General 25%

United States

Item No.					
421.42	Crude (salt cake)*	free			
		On and After January 1			
		1969	1970	1971	1972
		(cents per long ton)			
421.44	Anhydrous	40	35	30	25
421.46	Crystallized (Glauber's salt)*	80	70	60	50

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated), 1972, TC Publication 452.

*Rates of duty for 1970, 1971 and 1972 were to become effective unless the European Economic Community and Britain had not proceeded with certain reductions provided for in their respective schedules annexed to the Geneva (1967) Protocol to GATT. These two participants have not so proceeded, and the President has proclaimed that the rate of duty under 1969 will continue in effect until the President proclaims that the two participants have agreed to proceed with reductions.

Stone

D. H. STONEHOUSE

Naturally occurring rock material, quarried or mined for industrial use with no change in its chemical state and with its physical character altered only by shaping or by sizing, is commercially termed 'stone'. Dimension stone is shaped for use as a building block, slab or panel. It may be rough, cut, sawn or polished and its application may depend on its strength, hardness, durability and ornamental qualities. Broken, irregular, screened and sized pieces constitute the crushed stone category. It is used mainly as an aggregate in concrete and asphalt, in highway and railway construction and as heavy riprap for facing wharves and breakwaters.

Dimension stone. Granite, limestone, marble and sandstone are the principal rock types from which building and ornamental stone is fashioned. Construction uses account for over 85 per cent of the consumption of building and ornamental stone produced and sold in Canada; the remainder is used as monumental stone.

Today in the building sector of the construction industry, granite, limestone and marble are used as facing stone in the form of cut and polished panels, in conjunction with steel and concrete for institutional and commercail buildings, while in residential buildings, the use of a limestone or sandstone ashlar, or coursing stone, is becoming increasingly popular. The emphasis has changed from stone used for structural qualities to stone used for its aesthetic qualities. The architect and contractor can design and build for lasting beauty using Canadian building stones.

Crushed stone. Crushed stone accounts for over 80 per cent of stone production. Many quarries which produce crushed stone are operated primarily to produce stone for other purposes – granite for building blocks and monuments, limestone for cement or lime manufacture, or for metallurgical use, marble for monuments and building panels, sandstone for riprap and cut stone. Quarries removing solid rock by drilling, blasting and crushing are not likely to be operated for small, local needs as are gravel pits and are therefore usually operated by large companies associated with the construction industry. Depending on cost and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt and as railway ballast and road metal. In these applications, it is subject to the same physical and chemical testing procedures as the gravel and sand aggregates.

Other uses for crushed stone include the manufacture of roofing granules from granite and marble, the production of poultry grit from limestone and granite and the production of rock wool from limestone and sandstone. Pulverized stone is used as follows: granite, limestone and sandstone as asphalt filler; limestone for dusting coal mines; limestone and marble for agricultural application.

In excess of 3.5 million tons of limestone is produced for chemical and metallurgical uses in the iron and steel industry, the glass industry, the pulp and paper industry and in sugar manufacture.

Stone production in Canada, either as dimension stone or as crushed stone, is used directly or indirectly by the construction industry except for small amounts used as monuments. Indirect usage includes that portion of the resource that is utilized by the chemical industry (mainly limestone) for the manufacture of lime, cement, iron and steel, all of which are associated with various phases of the construction industry. Activity in both building construction and heavy or engineering construction can be indicative of demands for quarried stone.

Canadian industry

Atlantic provinces. *Limestone.* At Corner Brook, Newfoundland, Westland Equipment quarries a high-calcium limestone for use by Bowaters Newfoundland Limited in the calcium-acid sulphite process of pulp preparation. About 20,000 tons a year is used.

Mosher Limestone Company Limited quarries a dolomitic limestone at Upper Musquodoboit, Nova Scotia. Pulverized material is sold for agricultural use throughout the Atlantic provinces. Sydney Steel Corporation produces a high-calcium, fossiliferous limestone at Irish Cove, Nova Scotia, and a high-purity dolomite at Frenchvale, Nova Scotia, both for use in the Sydney steel plant. A quarry providing sized limestone to Scott Paper Limited at Abercrombie, Nova Scotia, was begun in 1968 near Antigonish Harbour by Calpo Limited. Marble Mountain Quarries Limited removed material from quarry stockpiles for crushing by Nova Scotia Sand and Gravel Limited and for use as an exposed aggregate in terrazzo tile and precast concrete panels. Extensive exploration for and assessment of limestones in Nova Scotia continues to

Table 1. Canada, total production (shipments) of stone, 1970 to 1972

	1970		1971		1972^p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
By province						
Newfoundland	182,400	282,600	204,091	577,021	200,000	600,000
Prince Edward Island	–	–	–	–	–	–
Nova Scotia	1,191,998	2,254,267	1,643,081	2,996,647	1,700,000	3,100,000
New Brunswick	1,321,454	2,773,433	1,431,075	2,900,250	1,500,000	3,000,000
Quebec	30,143,792	38,580,761	37,515,419	44,108,629	37,250,000	42,250,000
Ontario	27,673,376	34,447,188	28,238,491	38,483,600	29,000,000	39,000,000
Manitoba	1,272,690	3,198,305	1,012,371	1,128,831	1,000,000	1,000,000
Alberta	166,147	612,506	183,609	708,570	200,000	800,000
British Columbia	3,370,983	5,826,690	3,286,705	5,633,525	3,350,000	5,500,000
Canada	65,322,840	87,975,750	73,514,842	96,537,073	74,200,000	95,250,000
By use[1]						
Building stone						
Rough	46,103	1,324,850	62,094	1,927,608		
Dressed	42,163	3,943,439	26,940	650,114		
Monumental, ornamental stone						
Rough	22,568	902,511	29,199	978,449		
Dressed	6,093	1,044,057	16,992	238,141		
Flagstone	8,293	27,237	4,177	63,623		
Curbstone	6,269	162,833	15,488	336,044		
Paving blocks	100	6,600	488	8,005		
Chemical and metallurgical						
Cement plants, foreign	1,224,026	1,356,889	817,464	775,687		
Lining, open-hearth furnaces	348,052	217,344	306,854	360,466		
Flux in iron and steel furnaces	1,511,037	1,768,269	1,433,522	2,122,067		
Flux in nonferrous smelters	174,974	178,449	167,469	219,779		
Glass factories	205,710	766,237	208,223	788,916		
Lime kilns, foreign	114,575	291,742	207,611	509,443		
Pulp and paper mills	328,265	1,145,773	276,778	993,976		
Sugar refineries	87,866	214,632	88,436	235,255		
Other chemical uses	710,407	936,196	507,600	702,126		
Pulverized stone						
Whiting (substitute)	138,595	168,576	158,002	543,636		
Asphalt filler	410,826	703,484	326,250	541,687		
Dusting, coal mines	8,599	36,867	10,420	58,640		
Agricultural purposes and fertilizer plants	936,555	2,851,295	857,153	1,942,910		
Other uses	350,597	668,361	417,621	939,188		
Crushed stone						
For manufacture of artificial stone	179,723	434,863	112,653	390,161		
Roofing granules	90,994	1,854,570	120,040	2,536,581		
Poultry grit	17,624	194,672	23,625	231,402		
Stucco dash	9,961	278,295	12,297	330,304		
Terrazzo chips	14,346	283,203	20,882	263,934		
Rock wool	1,039	1,350	5,329	5,242		
Rubble and riprap	1,663,490	1,852,626	2,089,090	3,047,744		
Concrete aggregate	10,985,693	13,010,302	10,634,570	13,189,010		
Asphalt aggregate	*	*	6,427,833	6,967,122		
Road metal	22,093,020	23,486,605	22,223,834	25,477,162		
Railroad ballast	4,666,820	5,394,266	3,136,233	4,311,731		
Other uses	18,918,457	22,469,357	22,769,675	24,850,920		
Total	65,322,840	87,975,750	73,514,842	96,537,073		

Source: Statistics Canada. ^p Preliminary; – Nil; * Included under other uses. [1] Breakdown by rise, 1971, by Statistics Section, Mineral Resources Branch.

provide mineral inventory data for prospective consumers.

In New Brunswick, limestone is quarried at three locations – Brookville, Elm Tree and Havelock – for use as a crushed stone, as an aggregate, or for agricultural application.

There are three cement producers and one lime manufacturing plant in the Atlantic provinces, each operating its own limestone quarry*.

Granite. Current operations in Nova Scotia are at Nictaux, Shelburne and Erinville. A grey granite is produced from three operations near Nictaux and from one quarry at Shelburne for use mainly in the monument industry, while a black granite from Shelburne and a diorite from Erinville are used as facing stone. In 1972 there was no production from old granite quarries in the Halifax, New Germany or Queensport areas. Quartzitic rock referred to as 'bluestone' is quarried at Lake Echo, north of Dartmouth, for use as facing stone. Crushed quartzite for use as an aggregate is produced at a number of locations within Halifax County. At Folly Lake in Colchester County a diorite rock is quarried mainly for use as railway ballast.

In New Brunswick, a red, fine- to medium-grained granite is quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites are available in the Hampstead (Spoon Island) district. In the Bathurst area, a brown-to-grey, coarse-grained granite is quarried upon demand, as is a salmon-coloured, medium-grained granite near Antinouri Lake, and a black, ferromagnesian rock in the Bocabec River area. Red granite is available in the St. George district. Granite for use as a crushed stone is produced near Fredericton and at two locations near Moncton.

Sandstone. A medium-grained, buff sandstone is quarried at Wallace, Nova Scotia, for use as heavy riprap and for dimension stone applications. Recently, considerable tonnages were used in the reconstruction of the fortress at Louisbourg. Small deposits in many parts of the province are quarried periodically for local use.

In New Brunswick, a red, fine to medium grained sandstone has been quarried in Sackville for use in construction of buildings on the Mount Allison University campus. Deposits are exploited from time to time throughout Kent and Westmorland counties for local projects and for highway work.

Quebec. *Limestone.* Limestone occurs in the St. Lawrence and Ottawa river valleys and in the Eastern Townships. Other major deposits in the province are located in the Lac Saint-Jean – Saguenay River area and in the Gaspé region. The limestones range geologically from Precambrian to Carboniferous, and vary widely in purity, colour, texture and chemical composition.

Of over 90 limestone producers in Quebec, about 50 are classed as stone quarries with non-cement, non-lime associations. These are located near major market areas such as Montreal, Quebec, Sherbrooke, Ottawa-Hull and Trois-Rivières and supply crushed stone to the construction industry mainly for use in concrete and asphalt and as highway subgrade. Between 70 and 80 per cent of all stone quarried in Quebec is limestone, of which about 85 per cent was used as a crushed stone.

The pulp and paper industry, the metallurgical industry and the agricultural industry each use substantial quantities of limestone. At Kilmar, in western Quebec, Dresser Industries Canada, Ltd., formerly Canadian Refractories Limited mines a magnesite-dolomite ore from which it produces refractory-grade magnesia and magnesia products.

Five companies operate a total of seven cement manufacturing plants in Quebec while lime is produced by four companies at four locations*.

A fine-grained, brownish grey, fossiliferous limestone is available in the St-Marc-des-Carrières region of Quebec. A fine-grained dolomite, meeting the Department of Transport specifications, is being quarried from a deposit with proven reserves of 30 million cubic yards near the site of the new Montreal International Airport at Ste-Scholastique for use in runway construction.

Limestone blocks and other shapes are produced for the construction trade in the Montreal region and at various locations throughout the province as the need arises. Marble has been produced in the Stukely and Philipsburg areas.

Granite. Nearly 60 per cent of Canada's granite production comes from Quebec from long-established operations in two general regions – the region north of the St. Lawrence and Ottawa rivers, including the Lac Saint-Jean area, and the region south of the St. Lawrence River. Precambrian rocks contain granites of various colours, compositions and textures: red, brown, pink and black granites in the Lac Saint-Jean area; a fine-grained pink granite and a black anorthositic rock near Alma, and in the St-Luger-de-Milot area; coarse-grained, blue-grey and dark green granites at Rivière-à-Pierre; black and grey gneissic rocks at Rivière-à-Pierre and at Notre-Dame-des-Anges; red-pink granite at St-Alban and a banded, pink-red gneiss at St-Raymond; fine-grained, pink-coloured granite in the Laurier-Guenette area and a grey-pink gneiss at L'Annonciation; an augen-type granite near Mont-Tremblant and a coarse-grained, brown granite in the St-Alexis-des-Monts area; grey-speckled, black and

*Reference should be made to the Cement and Lime sections of the *Canadian Minerals Yearbook 1972.*

Table 2. Canada, production (shipments) of limestone, 1970-71

	1970		1971	
	(short tons)	($)	(short tons)	($)
By province				
Newfoundland	82,400	82,600	250	462
Nova Scotia	325,897	807,609	326,572	732,603
New Brunswick	285,283	912,286	425,810	1,096,791
Quebec	26,687,935	28,295,310	33,133,303	35,003,376
Ontario	26,517,386	30,428,000	27,193,671	33,382,138
Manitoba	913,824	1,816,995	973,071	651,381
Alberta	166,147	612,506	183,320	702,202
British Columbia	2,917,425	4,608,484	2,787,609	4,269,925
Canada	57,896,297	67,563,790	65,023,606	75,838,878
By use[1]				
Building stone				
Rough	5,982	57,907	4,187	59,099
Dressed	23,222	867,632	8,592	304,266
Monumental and ornamental				
Rough	1,704	41,136	727	22,286
Dressed	1,063	13,824	2,455	31,438
Flagstone	8,084	21,037	2,593	33,268
Curbstone	579	5,700	–	–
Paving blocks	100	6,600	–	–
Chemical and metallurgical				
Cement plants, foreign	1,184,088	1,272,621	817,464	775,687
Lining, open-hearth furnaces	348,052	217,344	306,854	360,466
Flux, iron and steel furnaces	1,511,037	1,768,269	1,433,522	2,122,067
Flux, nonferrous smelters	174,974	178,449	167,469	219,779
Glass factories	205,710	766,237	208,223	788,916
Lime kilns, foreign	114,575	291,742	207,611	509,443
Pulp and paper mills	328,165	1,074,557	276,778	993,976
Sugar refineries	87,866	214,632	88,436	235,255
Other chemical uses	710,407	936,196	507,600	702,126
Pulverized stone				
Whiting substitute	138,595	168,576	158,002	543,636
Asphalt filler	289,547	483,325	260,493	407,416
Dusting, coal mines	8,599	36,867	10,420	58,640
Agricultural purposes and fertilizer plants	922,625	2,821,001	842,712	1,906,705
Other uses	349,327	662,011	371,330	811,552
Crushed stone				
For artificial stone	163,723	408,343	105,157	374,593
Roofing granules	3,495	23,216	2,718	26,840
Poultry grit	10,800	108,224	18,180	163,645
Stucco dash	9,961	278,295	11,297	321,304
Terrazzo chips	210	1,260	142	994
Rock wool	1,039	1,350	5,329	5,242
Rubble and riprap	928,301	1,022,154	1,412,889	1,549,860
Concrete aggregate	9,241,866	9,679,351	9,039,935	9,982,009
Asphalt aggregate	*	*	5,617,029	5,670,019
Road metal	19,142,421	19,189,607	19,409,826	21,314,246
Railroad ballast	3,997,711	4,260,231	2,152,339	2,514,409
Other uses	17,982,469	20,686,096	21,573,297	23,029,696
Total	57,896,297	67,563,790	65,023,606	75,838,878

Source: Statistics Canada. – Nil; * Included under other uses. [1] Breakdown by use, 1971, by Statistics Section, Mineral Resources Branch.

Table 3. Canada, production (shipments) of marble, 1970-71

	1970		1971	
	(short tons)	($)	(short tons)	($)
By provinces				
Quebec	53,365	127,279	166,816	388,050
Ontario	8,470	223,624	9,615	173,074
Total, Canada	61,835	350,903	176,431	561,124
By use[1]				
Building stone				
Rough	–	–	–	–
Dressed	–	–	–	–
Pulverized stone				
Whiting substitute	–	–	–	–
Agricultural purposes and fertilizer plants	13,571	28,499	14,000	34,000
Other uses	–	–	43,691	111,584
Crushed stone				
For manufacture of artificial stone	–	–	1,000	9,000
Roofing granules	–	–	6,000	29,600
Poultry grit	–	–	–	–
Stucco dash	–	–	1,000	9,000
Terrazzo chips	13,473	279,611	20,740	262,940
Rock wool	–	–	–	–
Concrete aggregate	2,665	3,278	15,000	20,000
Asphalt aggregate	–	–	35,000	40,000
Road metal	32,038	39,407	40,000	45,000
Other uses	88	108	–	–
Total	61,835	350,903	176,431	561,124

Source: Statistics Canada. – Nil. [1] Breakdown by use, 1971, by Statistics Section, Mineral Resources Branch.

gabbroic rock in the Montpellier area and a dark-coloured anorthositic rock in the Rouyn area; brown-red to green-brown syenites in the Grenville District, a mauve-red granite in the Ville-Marie area on Lake Timiskaming. Many areas underlain by granite are too remote from transportation and markets to be economically attractive.

In the region south of the St. Lawrence River, granites are much younger and are essentially greyish.

Sandstone. In 1972 there were 14 mining operations in Quebec in which sandstone was being quarried for construction uses. The material was used as a facing stone and as an aggregate. Deposits in the vicinity of Trois-Pistoles and near Quebec City are available for exploitation.

Ontario. *Limestone.* Although limestones in Ontario range from Precambrian through Devonian, the major production comes from Ordovician, Silurian and Devonian deposits. Of particular importance are the limestones and dolomites from the following geological sequences: the Black River and Trenton formations, extending from the lower end of Georgian Bay across southern Ontario to Kingston; the Guelph-Lockport Formation, extending from Niagara Falls to the Bruce Peninsula and forming the Niagara Escarpment; and the Middle Devonian limestones extending from Fort Erie through London and Woodstock to Lake Huron. Production of building stone, fluxstone and crushed aggregate from the limestones of these areas amounted to over 90 per cent of total stone production in Ontario during 1972.

Marble, ranging from blue to pink, has been quarried for construction purposes from deposits near Perth. Marble is widely distributed over southeastern Ontario and, according to Ontario Department of Mines reports, underlies as much as 100 square miles.

The limestone industries of Ontario are described in detail in publications of the Ontario Department of Mines.

Eight companies operated a total of ten lime-producing facilities in Ontario in 1972 and four companies produced portland cement at a total of six locations*. Crushed stone was shipped from most of these plants.

* See Cement and Lime sections of the *Canadian Minerals Yearbook 1972* preprints Nos. 10 and 24).

Granite. Granites occur in northern, northwestern and southeastern Ontario. Few deposits have been exploited for the production of building stone because the major consuming centres are in southern and southwestern Ontario, where ample, good-quality limestones and sandstones are readily available for building. The areas most active in granite building stone production have been the Vermilion Bay area near Kenora, the River Valley area near North Bay, and the Lyndhurst-Gananoque area in southeastern Ontario. Rough building blocks were quarried from a gneissic rock near Parry Sound, while at Havelock a massive red-granite rock was quarried.

Table 4. Canada, production (shipments) of granite, 1970-71

	1970		1971	
	(short tons)	($)	(short tons)	($)
By provinces				
Newfoundland	–	–	22,218	121,416
Nova Scotia	157,131	182,328	10,624	75,687
New Brunswick	1,016,553	1,740,097	809,570	1,438,798
Quebec	1,807,475	7,752,217	2,563,973	6,073,266
Ontario	1,128,364	3,559,700	1,019,562	4,672,792
Manitoba	358,866	1,381,310	39,300	477,450
British Columbia	368,850	616,239	283,554	457,390
Total, Canada	4,837,239	15,231,891	4,748,801	13,316,799
By use[1]				
Building stone				
Rough	21,981	942,137	40,690	1,579,155
Dressed	11,921	2,934,302	9,800	205,750
Monumental and ornamental				
Rough	20,864	861,375	28,472	956,163
Dressed	5,030	1,030,233	14,537	206,703
Flagstone	–	–	425	14,250
Curbstone	5,190	151,235	7,388	276,044
Paving blocks	–	–	–	–
Chemical uses				
Pulp and paper mills	100	71,216	–	–
Pulverized stone				
Asphalt filler	3,279	9,169	2,857	8,471
Other pulverized uses	–	–	500	5,552
Crushed stone				
For artificial stone	16,000	26,520	–	–
Roofing granules	79,234	1,812,082	105,322	2,466,641
Poultry grit	4,477	73,540	3,445	56,757
Stucco dash	–	–		
Rubble and riprap	692,934	792,449	634,067	1,450,080
Concrete aggregate	1,001,042	1,668,426	1,011,131	1,732,629
Asphalt aggregate	*	*	419,753	664,035
Road metal	1,860,701	2,910,502	766,350	1,066,353
Railroad ballast	243,601	297,898	507,686	806,992
Other uses	870,885	1,650,807	1,196,378	1,821,224
Total	4,837,239	15,231,891	4,748,801	13,316,799

Source: Statistics Canada. * Included under other uses; – Nil. [1] Breakdown by uses, 1971, by Statistics Section, Mineral Resources Branch.

Table 5. Canada, production (shipments) of sandstone, 1970-71

	1970		1971	
	(short tons)	($)	(short tons)	($)
By provinces				
Newfoundland	100,000	200,000	181,623	455,143
Nova Scotia	708,970	1,264,330	1,305,885	2,188,357
New Brunswick	13,721	67,171	195,695	364,661
Quebec	1,487,110	2,366,343	1,606,647	2,625,184
Ontario	19,156	235,864	15,643	255,596
Alberta	–	–	289	6,368
Canada	2,328,957	4,133,708	3,305,782	5,895,309
By use[1]				
Building stone				
Rough	18,140	324,806	17,217	289,354
Dressed	7,020	141,505	8,548	140,098
Flagstone	209	6,200	1,159	16,105
Curbstone	500	5,898	8,100	60,000
Paving blocks	–	–	488	8,005
Pulverized stone				
Asphalt filler	118,000	210,990	62,900	125,800
Agricultural purposes and fertilizer plants	359	1,795	441	2,205
Crushed stone				
For artificial stone	–	–	6,496	6,568
Roofing granules	8,265	19,272	6,000	13,500
Poultry grit	2,347	12,908	2,000	11,000
Terrazzo chips	663	2,332	–	–
Rubble and riprap	42,255	38,023	42,134	47,804
Concrete aggregate	690,723	1,094,019	414,903	675,035
Asphalt aggregate	*	*	356,051	593,068
Road metal	949,953	1,307,477	1,947,817	2,935,190
Road ballast	425,508	836,137	431,528	971,577
Other uses	65,015	132,346	–	–
Total	2,328,957	4,133,708	3,305,782	5,895,309

Source: Statistics Canada. – Nil. * Included under other uses. [1] Breakdown by use, 1971, by Statistics Section, Mineral Resources Branch.

Sandstone. Sandstone quarried near Toronto, Ottawa and Kingston, has been used widely in Ontario as building stone. Production is currently from the Limehouse-Georgetown-Inglewood district where Medina sandstone is quarried and from the Kingston area where Potsdam sandstone is quarried. Medina sandstones vary from grey, through buff and brown to red and are also mottled. They are fine to medium grained. The Potsdam stone is medium grained and the colour ranges from grey-white through salmon-red to purple and it also can be mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar and flagstone.

Western provinces. *Limestone.* From east to west through the southern half of Manitoba, rocks of the following geological ages are represented – Precambrian, Ordovician, Silurian, Devonian and Cretaceous. Limestones of commercial importance occur in the three middle classifications and range from magnesian limestone through dolomite to high-calcium limestones. Although building stone does not account for a large percentage of total limestone produced, perhaps the best known of the Manitoba limestones is Tyndall Stone, a mottled dolomitic limestone often referred to as 'tapestry' stone. It is widely accepted as an attractive building stone and is quarried at Garson, Manitoba, about 30 miles northeast of Winnipeg.

Limestone from Moosehorn, 100 miles northwest of Winnipeg, and from Mafeking, 25 miles east of the Saskatchewan border and 100 miles south of The Pas, is transported to Manitoba and Saskatchewan centres for use in metallurgical, chemical, agricultural and construction industries. Limestone from Steep Rock

Table 6. Canada, production (shipments) of shale, 1970-71

	1970		1971	
	(short tons)	($)	(short tons)	($)
By province				
New Brunswick	5,897	53,879	–	–
Quebec	107,907	39,612	44,680	18,753
British Columbia	84,708	601,967	215,542	906,210
Canada	198,512	695,458	260,222	924,963
By use[1]				
Chemical and metallurgical				
Cement plants, foreign	39,938	84,268	–	–
Pulverized stone				
Other uses	1,270	6,350	2,100	10,500
Crushed stone				
Concrete aggregate	49,397	565,228	153,601	779,337
Road metal	107,907	39,612	59,841	116,373
Rail and ballast	–	–	44,680	18,753
Other uses	–	–		
Total	198,512	695,458	260,222	924,963

Source: Statistics Canada. – Nil. [1] Breakdown by use, 1971, by Statistics Section, Mineral Resources Branch.

Table 7. Canada, production (shipments) of stone by types, 1962-72

	Granite		Limestone		Marble		Sandstone	
	(short tons)	($)	(short tons)	($)	(short tons)	($)	(short tons)	($)
1962	5,386,880	13,942,156	41,551,585	50,315,116	71,888	707,724	3,492,071	3,735,957
1963	5,679,264	15,070,882	51,021,396	58,053,321	71,714	755,889	5,732,276	5,776,107
1964	7,310,629	16,854,742	57,019,890	63,140,728	95,455	891,617	4,433,555	5,264,849
1965	7,829,220	16,569,762	62,178,833	69,974,005	78,440	1,049,264	4,172,981	5,328,404
1966	19,598,325	25,423,394	69,760,441	77,431,007	157,789	1,190,592	5,202,281	5,949,172
1967	19,876,638	29,016,622	57,155,517	66,062,095	191,286	1,093,024	6,350,611	7,103,735
1968	16,654,735	23,310,531	54,538,796	65,619,953	165,007	637,845	4,267,391	5,136,658
1969	5,399,812	15,832,160	59,610,356	67,219,003	85,848	390,599	2,275,996	4,203,388
1970	4,837,239	15,231,891	57,896,297	67,563,790	61,835	350,903	2,328,957	4,133,708
1971	4,748,801	13,316,799	65,023,606	75,838,878	176,431	561,124	3,305,782	5,895,309
1972^p	..	..	..	..	..	..	..	..

	Shale		Slate		Total	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
1962	45,686	149,684	5,375	15,721	50,553,485	68,866,358
1963	104,130	199,070	46,549	28,150	62,655,329	79,883,419
1964	743,564	621,197	191,265	109,550	69,794,358	86,882,683
1965	2,338,460	1,837,492	160,171	88,094	76,758,105	94,847,021
1966	1,103,218	974,544	–	–	95,822,054	110,968,709
1967	433,256	612,796	–	–	84,007,308	103,888,272
1968	313,838	953,088	–	–	75,939,767	95,658,075
1969	105,000	541,112	–	–	67,477,012	88,186,262
1970	198,512	695,458	–	–	65,322,840	87,975,750
1971	260,222	924,963	–	–	73,514,842	96,537,073
1972^p	..	..	..	..	74,200,000	95,250,000

Source: Statistics Canada. ^{p}Preliminary; .. Not available; – Nil.

and from Lily Bay is used by cement manufacturers in Winnipeg and limestone from Faulkner is now being used by the lime plant at Spearhill. The possibility of utilizing marl, an unconsolidated calcareous material, from deposits in the Sturgeon Lake region, for the pulp and paper, cement and lime industries has been investigated.

The eastern ranges of the Rocky Mountains contain limestone spanning the geological ages from Cambrian to Triassic with major deposits in the Devonian and Carboniferous systems in which a wide variety of types occurs. In southwestern Alberta high-calcium limestone is mined at Exshaw, Kananaskis and Crowsnest chiefly for the production of cement and lime, for metallurgical and chemical uses and for use as a crushed stone. Similar uses are made of limestone quarried at Cadomin, near Jasper.

In British Columbia, large volumes of limestone are mined each year for cement and lime manufacture, for use by the pulp and paper industry and for various construction applications. A large amount is exported to northwestern United States for cement and lime manufacture. Four companies mined limestone on Texada Island with the entire output being moved by barge to Vancouver and to the State of Washington. One company, Ideal Basic Industries, Inc., announced plans to increase output to 3.6 million tons a year. Other operations, at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Doeye River and Cobble Hill, produced stone for construction use, for filler use, and cement manufacture. Beginning in 1969, shipments of limestone from a new quarry on Aristazabal Island, 350 miles north of Vancouver, were made to the Portland, Oregon area by Laredo Limestone Ltd. During 1972 Thyssen Mining Construction of Canada Ltd. displayed interest in developing a 1-million-ton-a-year operation on Aristazabal Island. During 1971 interest was revived in the possible use of travertine from a British Columbia source.

Eight cement plants and seven lime plants were operated in western Canada in 1971*.

Granite. In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, red granite is quarried for building and monumental use. Grey granite east of Winnipeg near the Ontario border, is a potential source of building stone.

In British Columbia, a light-grey to blue-grey, even-grained granodiorite of medium texture is available from Nelson Island. An andesite has been quarried at Haddington Island, off the northeast coast of Vancouver Island, for use as a building stone.

* See Cement and Lime sections of the *Canadian Minerals Yearbook 1972* (preprints Nos. 10 and 24).

Table 8. Canada, stone imports and exports, 1970-72

	1970		1971		1972^p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Exports						
Building stone, rough	21,062	889,000	19,230	869,000	15,900	761,000
Natural stone basic products	..	3,215,000	..	2,879,000	..	2,529,000
Total		4,104,000		3,748,000		3,290,000
Imports						
Stone, crude, nes	2,377	49,000	2,185	32,000	956	59,000
Building stone, rough, nes	14,697	528,000	13,145	535,000	10,983	456,000
Granite, rough	13,048	567,000	13,254	549,000	12,705	637,000
Marble, rough	4,676	378,000	2,199	275,000	3,292	373,000
Shaped or dressed granite	..	408,000	..	1,161,000	..	826,000
Shaped or dressed marble	..	666,000	..	785,000	..	989,000
Natural stone basic products, nes	..	195,000	..	216,000	..	252,000
Total		2,791,000		3,553,000		3,592,000

Source: Statistics Canada.
^{p}Preliminary; .. Not available; nes Not elsewhere specified.

Sandstone. Sandstone for building and ornamental uses, quarried near Banff, Alberta, is hard, fine grained, medium grey and is referred to as 'Rundal Stone'.

The environment

There is justifiable concern for the future development, operation and rehabilitation of pits and quarries in all locations, especially in and near areas of urban development. Although an open pit mining operation close to residential areas is seldom desirable, non-renewable mineral resources have to be wisely used. Where urban sprawl has been unexpectedly rapid, conflicts for land use can materialize and potential sources of raw mineral materials for the construction industry can be overrun. Master plans are required to co-ordinate all phases of development so that mineral exploitation is part of the urban growth pattern.

Rehabilitation of a stone quarry to permit subsequent land use is generally more difficult and more costly than for gravel pits. They do provide the same disruptions to the natural environment and to urban development and are therefore included in continuing studies to plan efficient land use. Legislation imposing strict controls has become necessary and although Ontario presently seems to be leading in this field, its newly enacted laws are typical of what can be expected in other provinces regarding urban spread and pit and quarry development. Ontario regulations apply to operations in designated areas and to rehabilitation of depleted sites. To date 68 townships have been designated. They are located along the Niagara Escarpment in the Toronto-centred region and in the Ottawa, Kingston and London areas. The Niagara Escarpment Protection Act, June 26, 1970, prohibits future mining on the escarpment face and for 300 feet back from the face. Regulations outlining requirements for licensing gravel pits and quarries, as well as standards for the rehabilitation of pit and quarry lands, were approved by the Ontario government on December 22, 1971.

Markets, outlook and trade

Limestones are widely distributed in Canada and generally are available in sufficient quantity and with such chemical or physical specifications that long transportation hauls are unnecessary. Limestone products are low-priced commodities and only rarely, when a market exists for a high-quality, specialized product such as white portland cement or a high-purity extender, are they beneficiated or moved long distances. Provided the specifications are met, the nearest source is usually considered, regardless of provincial or national boundaries.

Over 70 per cent of Canada's annual production of limestone is used as a crushed stone. This includes about 50 per cent used as road metal (broken, screened stone for macadam roads), about 20 per cent

Table 9. Value of construction in Canada, 1971-73

	1971	1972	1973[1]	Change 1972-73
	(millions of dollars)			(%)
Building construction				
Residential	4,975.9	5,760.4	5,853.3	+1.6
Industrial	1,023.0	898.2	881.2	−1.9
Commercial	1,405.1	1,602.6	1,897.3	+18.4
Institutional	1,456.0	1,303.2	1,187.4	−8.9
Other building	506.9	541.6	578.6	+6.8
Total	9,366.9	10,106.0	10,397.8	+2.9
Engineering construction				
Marine	119.0	140.4	184.0	+31.1
Highways, aerodromes	1,588.3	1,617.7	1,692.3	+4.6
Waterworks, sewage systems	593.4	712.3	777.6	+9.2
Dams, irrigation	56.3	71.9	66.7	−7.2
Electric power	1,206.4	1,275.9	1,605.4	+25.8
Railways, telephones	615.4	704.5	783.9	+11.3
Gas and oil facilities	1,290.0	1,388.9	1,502.5	+8.2
Other engineering	1,029.6	1,009.9	1,047.7	+3.7
Total	6,498.4	6,921.5	7,660.1	+10.7
Total construction	15,865.3	17,027.5	18,057.9	+6.1

Source: Statistics Canada.
[1] Intentions.

Table 10. Canada, value of construction work performed by principal type of construction, by industry, 1970-73

Industry	1970 Building	1970 Engineering	1970 Total	1971 Building	1971 Engineering	1971 Total	1972 Building	1972 Engineering	1972 Total	1973[1] Building	1973[1] Engineering	1973[1] Total
	(millions of dollars)											
Agriculture and fishing	204	110	314	206	112	318	234	126	360	251	135	386
Forestry	7	56	63	5	56	61	7	60	67	9	78	87
Mining, quarrying, oil wells	165	968	1,133	348	1,116	1,464	226	1,089	1,315	139	1,187	1,326
Construction	21	–	21	24	–	24	22	–	22	22	–	22
Manufacturing	851	360	1,211	693	388	1,081	654	352	1,006	678	444	1,122
Utilities	263	2,158	2,421	208	2,413	2,621	220	2,600	2,820	251	2,965	3,216
Trade	278	10	288	232	14	246	257	10	267	295	15	310
Finance, insurance, real estate	455	7	462	533	13	546	702	81	783	884	85	969
Commercial services	149	4	153	244	2	246	228	1	229	283	2	285
Housing	4,009	–	4,009	4,976	–	4,976	5,760	–	5,760	5,853	–	5,853
Institutional services	1,186	13	1,199	1,304	14	1,318	1,133	14	1,147	1,005	16	1,021
Government departments	510	1,997	2,507	594	2,370	2,964	633	2,589	3,252	728	2,733	3,461
Total	8,098	5,683	13,781	9,367	6,498	15,865	10,106	6,922	17,028	10,398	7,660	18,058

Source: Statistics Canada.
[1]Intentions; – Nil.

used as concrete aggregate and about 2 per cent used as railroad ballast.

Some major uses in the chemical field are: neutralization of acid waste liquors; extraction of aluminum oxide from bauxite; manufacture of soda ash, calcium carbide, calcium nitrate and carbon dioxide; in pharmaceuticals; as a disinfectant; in the manufacture of dyes, rayons, paper, sugar and glass; and in the treatment of water. Dolomitic limestone is used in the production of magnesium chloride and other magnesium compounds.

Limestone is used in the metallurgical industries as a fluxing material, where it combines with impurities in ore to form a fluid slag that can be separated from molten metal. Calcium limestones are used in open-hearth steel manufacture whereas both calcium limestones and dolomitic limestones are used as a flux in the production of pig iron in blast furnaces.

Limestone is used extensively as a filler or an extender and, where quality permits, as a whiting. In such applications both physical and chemical properties are important. Specifications vary widely but in general, a uniform, white material passing 325 mesh would meet the physical requirements. Whiting is used in ceramic bodies, plastics, floor coverings, insecticides, paper, wood putty, rubber, paints and as a filler in many other commodities. In paint manufacture, the material may be used as a pigment extender.

Agricultural limestone is used to control soil acidity and to add calcium and magnesium to the soil. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomite is the source of magnesium metal produced at Haley, Ontario; the company also uses a high-calcium lime from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone, for use as a refactory, is produced at Dundas, Ontario.

Limestone from deposits in coastal areas of British Columbia is mined, crushed, loaded to barges of up to 20,000 tons capacity, and transported as much as 400 miles to consuming centres along the west coast in both Canada and the United States. One Canadian company, Domtar Chemicals Limited, manufactures lime at Tacoma, Washington, using limestone from Texada Island.

Crushed stone will continue to compete with sand and gravel for major markets where the latter are scarce. Through vertical integration, large operations based on construction materials can, by mergers and acquisitions, obtain captive markets for their products in operating construction firms. Construction firms can also integrate backwards into the resource field.

The possibility of substitutes for aggregates is not likely to occur soon in Canada although in countries where such resources are scarce other materials such as compressed garbage are being used. The use of lime or cement to stabilize soils could reduce the amount of aggregate fill required on some highway or railway projects.

Trade, mostly with the United States, is minimal and probably takes place in immediate border regions where transportation costs rather than quality of material are the main reason for using a foreign material.

Traditional markets for building stone have been lost to competitive building materials such as steel and concrete. Modern design and construction methods favour the flexibility offered by the use of steel and precast or cast-in-place concrete. For aesthetic qualities not available elsewhere, rough or polished stone is used in many modern structures. Monumental stone continues to be in demand.

The present structure of the building stone industry in Canada is unlikely to change very soon. Recent efforts have been made on behalf of the industry to illustrate to contractors and architects the availability of a wide range of Canadian building stones and their adaptability in modern building design.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
29635-1	Limestone, not further processed than crushed or screened	free	free	25
30500-1	Flagstone, sandstone and all building stone, not hammered, sawn or chiselled	free	free	20
30505-1	Marble, rough, not hammered or chiselled	10	10	20
30510-1	Granite, rough, not hammered or chiselled	free	free	20
30515-1	Marble, sawn or sand rubbed, not polished	free	10	35
30520-1	Granite, sawn	free	7½	35
30525-1	Paving blocks of stone	free	7½	35
30530-1	Flagstone and building stone, other than marble or granite, sawn on not more than two sides	free	7½	35

Tariffs (concl'd)

Canada (concl'd)

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
30605-1	Building stone, other than marble or granite, sawn on more than two sides but not sawn on more than four sides	5	7½	10
30610-1	Building stone, other than marble or granite, planed, turned, cut or further manufactured than sawn on four sides	7½	12½	15
30615-1	Marble, not further manufactured than sawn, when imported by manufacturers of tombstones to be used exclusively in the manufacture of such articles, in their own factories	free	15	20
30700-1	Marble, nop	17½	17½	40
30705-1	Manufactures of marble, nop	17½	17½	40
30710-1	Granite, nop	17½	17½	40
30715-1	Manufactures of granite, nop	17½	17½	40
30800-1	Manufactures of stone, nop	17½	17½	35
30905-1	Granules, whether or not coloured or coated, for use in manufacture of roofing, including shingles and siding	free	free	25
30900-1	Roofing slate, per square of 100 square feet	free	free	75¢

United States

Item No.		On and After January 1 1970	1971	1972
513.61	Granite, not manufactured, and not suitable for use as monumental, paving or building stone	free	free	free
514.11	Limestone, crude, not suitable for use as monumental, paving or building stone, per short ton	14¢	12¢	10¢
		(%)	(%)	(%)
513.21	Marble, chips and crushed	7	6	5
514.91	Quartzite, whether or not manufactured	free	free	free
515.11	Roofing slate	17	15	12.5
515.14	Other slate	7	6	5
515.41	Stone, other, not manufactured and not suitable for use as monumental, paving or building stone	free	free	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.
Note: Varying tariffs are in effect on the more fabricated stone categories.
nop Not otherwise provided for.

Sulphur

G.H.K. PEARSE

Sulphur, one of the most important and versatile industrial raw materials, is widely distributed throughout the world in both elemental and combined states. It has been used by man since antiquity and today all industries use sulphur in some form, principally as a processing and manufacturing reagent. More than half of the world's sulphur output is in elemental form, nearly all obtained from native sulphur deposits and sour natural gas. The remainder is recoverd from pyrite and smelter stack gases principally as sulphuric acid, in which form 87 per cent of all sulphur is consumed. Fertilizer manufacture accounts for about half of all sulphur consumed followed by chemicals, pigments and pulp and paper as the next largest consuming sectors.

World sulphur production in all forms reached an estimated 47 million metric tons in 1972, exceeding demand for the fifth consecutive year. Western world production rose to 33.5 million metric tons and consumption increased 6 per cent over 1971 to 32.0 million metric tons, largely as a result of renewed vigour in the world fertilizer industry. Canada's total elemental sulphur sales in 1972 were 12 per cent more than in 1971. Under the influence of expanded trade, all producing countries' stocks, except Canada's, declined.

Prices, which have been declining since mid-1968 under the pressure of oversupply, diminished still further during 1972.

The Canadian sulphur industry

Canadian sulphur is obtained from three sources: elemental sulphur derived from sour natural gas and petroleum, sulphur recovered from smelter gases in the form of sulphuric acid, and sulphur contained in pyrite concentrates which are used in sulphuric acid manufacture. Minor tonnages of elemental sulphur are recovered as a byproduct of electrolytic refining of nickel sulphide matte and a small quantity of liquid sulphur dioxide is produced from pyrites and smelter gases. Eighty-four per cent of Canadian sulphur shipments in 1972 were in elemental form, virtually all from sour natural gas in western Canada.

Dramatic growth over the last 10 years in the Canadian sulphur industry is due almost entirely to expanded exploitation and treatment of sour natural gas, principally in Alberta. Canadian production of sulphur in all forms in 1960 was one million long tons, elemental sulphur making up only one quarter of the total. In 1972 total sulphur production is estimated at 7.34 million long tons, some 6.76 million tons in elemental form. Since 1968, Canada has been the world's largest supplier of elemental sulphur.

Canadian sulphur shipments in all forms in 1972 are reported (Table 1) as 3,536,400 long tons valued at $24,311,000. From information received during the first quarter of 1973, this figure is likely to be revised upwards to 3,910,000 long tons valued at $26,379,300. The latter figures represent a tonnage increase of 12 per cent and a value decrease of one per cent compared with 1971.

Hydrocarbon sources

Hydrocarbons contain sulphur in some form in at least minute amounts. Where the sulphur content is unacceptably high, as it is in many gas reservoirs in western Canada, it must be removed. Sulphur produced from hydrogen sulphide (H_2S), the dominant sulphur compound occurring in sour natural gas, is presently the most important source in Canada. Because of the need to strip high corrosive and toxic hydrogen sulphide from gas prior to marketing, the elemental sulphur produced is, therefore, an involuntary byproduct of natural gas operations.

Sulphur recovery in Canada from Athabasca oil sands and crude oil is comparatively minor at present and from coal is virtually nil. However, with ever-increasing energy requirements and more and more stringent air pollution regulations coming into force, these vast sources of sulphur will, in the foreseeable future, contribute substantially to world supply.

Sour natural gas. Although the H_2S content of sour gas fields ranges as high as 87 per cent by weight of the total raw gas in place, most of the producing fields contain from 1 to 20 per cent H_2S.

The modified Claus process in one of its variants is used to recover sulphur from sour natural gas. Briefly, the method is as follows: H_2S is extracted by absorption into a solution of one of the following: diethanolamine, monoethanolamine, hot potassium carbonate, or sulfinol. The solution is then heated in a stripper tower where H_2S is evolved. The H_2S passes into a furnace where a controlled air flow results in partial oxidation of H_2S to permit the following reactions:

$$2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$$
$$2H_2S + SO_2 \rightarrow 2H_2O + 3S$$

Table 1. Canada, sulphur production and trade, 1971-72

	1971		1972[p]	
	(long tons)[4]	($)	(long tons)	($)
Production (shipments)				
Pyrite and pyrrhotite[1]				
Gross weight	283,864		116,000	
Sulphur content	138,421	1,161,800	53,600	495,000
Sulphur in smelter gases[2]	552,185	4,632,467	562,500	5,223,000
Elemental sulphur[3]	2,811,677	21,299,520	2,920,300	18,593,000
Total sulphur content	3,502,283	27,093,787	3,536,400	24,311,000
Imports				
Sulphur, crude or refined				
United States	27,482	745,000	20,180	567,000
Mexico	–	–	4,910	103,000
Total	27,482	745,000	25,090	670,000
Exports				
Sulphur in ores (pyrite)				
United States	. .	1,074,000	. .	502,000
Sulphuric acid and oleum (contained S)				
United States	33,000	2,323,981	34,000	2,533,298
Other countries	32	. .	31	. .
	33,032		34,031	
Sulphur, crude or refined, nes				
United States	900,351	10,417,000	893,912	8,035,000
Australia	219,984	2,848,000	281,194	3,514,000
New Zealand	152,228	2,526,000	158,843	2,328,000
People's Republic of China	–	–	188,109	2,229,000
India	148,068	1,697,000	194,404	2,080,000
France	64,662	542,000	125,611	1,971,000
Taiwan	106,082	1,222,000	181,171	1,760,000
Brazil	42,389	514,000	123,037	1,321,000
Italy	105,239	1,520,000	89,135	1,122,000
Netherlands	40,097	581,000	71,761	1,038,000
South Korea	127,096	1,063,000	93,069	794,000
Other countries	457,842	4,202,000	142,488	1,345,000
Total	2,364,038	27,132,000	2,542,734[2]	27,537,000

Source: Statistics Canada, Mineral Resources Branch.
[1]Producers' shipments of byproduct pyrite and pyrrhotite from the processing of metallic sulphide ores. [2]Sulphur in liquid SO_2 and H_2SO_4 recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates. [3]Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oils and from the treatment of nickel-sulphide matte. [4]Except where indicated, all tonnages referred to are long tons in this review.
[p]Preliminary; – Nil; . . Not available; nes Not elsewhere specified.

Gas from this furnace enters a condenser-converter series and a portion of liquid sulphur is removed from the vapour in each unit. Overflow gases then pass through another reaction furnace and the process is repeated until 95 per cent or more of the original sulphur has been removed. The tail gases are incinerated and released to the atmosphere and liquid sulphur is fed into an underground storage pit for pumping to outside storage blocks where it cools and solidifies. Alternatively, the liquid is fed into a slating plant where it is quenched in water on a special belt subsequently breaking up into 'slates'. Slated sulphur is claimed to be superior to bulk because it is dust-free and easier to handle. All offshore shipments are now in slated form.

Canada's first sour natural gas sulphur recovery plant came on stream in Alberta in 1951, and sulphur output in 1952 amounted to 8,000 long tons. In 1972, 45 plants were operating, including one in Saskatchewan and two in British Columbia with a combined daily capacity* of 24,913 long tons. Production of elemental sulphur in Alberta as reported by the Alberta Energy Resources Conservation Board was 6,547,743 long tons, an increase of 46 per cent over 1971. Production in British Columbia was 66,396 long tons and in Saskatchewan was 3,070 long tons in 1972 giving a total for the year of 6,617,209 million long tons of elemental sulphur derived from sour gas.

According to the Alberta Energy Resources Conservation Board, Alberta's recoverable reserves of sulphur from sour gas fields amounted to an estimated 165.6 million long tons at the end of 1972.

Alberta sulphur sales were 3,105,584 long tons in 1972, up 15 per cent after a poor year in 1971. However, the downward pressure on sulphur prices from world oversupply continued throughout the year and value of sales declined from $19,283,770 in 1971 to $17,719,397 in 1972. Alberta inventories stood at 8,657,911 long tons at year-end. Elemental sulphur sales from British Columbia and Saskatchewan were 50,555 long tons and 1,682 long tons, and inventories were 95,105 long tons and 8,000 long tons, respectively, in 1972.

Elemental sulphur productive capacity in Canada has doubled during the last four years as a result of extensive sour gas discoveries made in response to a strong demand for natural gas, particularly in the United States. During the year, additional sour gas reserves were discovered in the Ricinus area, the source for the recently completed Ram River plant. With a lag of three to four years between discovery and plant start-up, a major increment in sulphur capacity may be in the offing after 1976.

In 1972 three new plants came on stream and expansions to two others raised daily capacity by 2,667 long tons to 24,913 long tons. The new plants are: Imperial Oil Limited, Joffre (27)**; Westcoast Transmission Company Limited, Fort Nelson (250); and Sun Oil Company Limited, Black Diamond (13). Expansions to existing plants completed in 1972 are: Aquitaine Company of Canada Ltd., Ram River – Stage 2 (4,000); Shell Canada Limited, Simonette (225) and Chevron Standard Limited, Nevis (258).

Several of the new plants and expansions which were slated for early 1971 were delayed until late in the year with the result that their impact was largely postponed until 1972. Reflecting this, production rose from 4.54 million long tons to 6.62 million long tons. Stage Two of Aquitaine Company of Canada Ltd.'s Ram River project was finished in October 1972 bringing the capacity of the combined stages to 4,000 long tons a day – the largest sour gas sulphur recovery unit in the world.

Additional capacity scheduled for 1973 involves only expansions to six plants. Most of the expansions are in response to more stringent pollution abatement guidelines laid down in November 1971 by the Alberta government. The guidelines include: mandatory stack cleanup facilities and recovery efficiencies between 97 and 99 per cent, depending on acid gas quality, for plants rating over 1,000 long tons a day; minimal stack cleanup or equipment with efficiency between 94 and 98 per cent for plants rated between 400 and 1,000 tons a day; at least a three-stage Claus unit or equivalent with efficiency between 92 and 96 per cent for 100- to 400-ton plants and for smaller plants, a two-stage Claus unit with recovery efficiency between 90 and 94 per cent. All plants must comply with this requirement by December 31, 1974.

The offshore market accounts for 70 per cent of Canada's exports. Sulphur destined for these markets is currently railed to loading terminals at Vancouver, some 650 miles from processing plants. In mid-1970, unit-train movement of sulphur was inaugurated, resulting in substantial savings in transportation costs. However, even with these savings, loading, transportation and terminal handling costs make up more than half of the fob Vancouver price.

In July 1972, Canadian offshore shipments of nonslated bulk sulphur ceased in compliance with an order issued by the Vancouver port authorities. The order was prompted by concern over alleged pollution by sulphur dust and the explosion hazard. This action froze vatted (bulk) stockpiles, effectively removing 8.8 million tons from available world supply at present prices. In addition, slating capacity, at 3.0 million long tons, was considerably strained, although planned capacity for the end of 1974 appears to be adequate for near-term requirements. However, a bottleneck which is becoming more serious with time is the limited storage capacity at Vancouver Harbour, a condition which limits the flexibility required to respond to surges in sulphur demand, to ensure against unpredictable delays in rail shipments and, under the close timing made necessary, to negotiate favourable rates on the ocean freight market.

*Daily capacity, which is based upon the designed maximum raw gas throughput, is never sustained throughout the year as gas sales are subject to seasonal fluctuations.

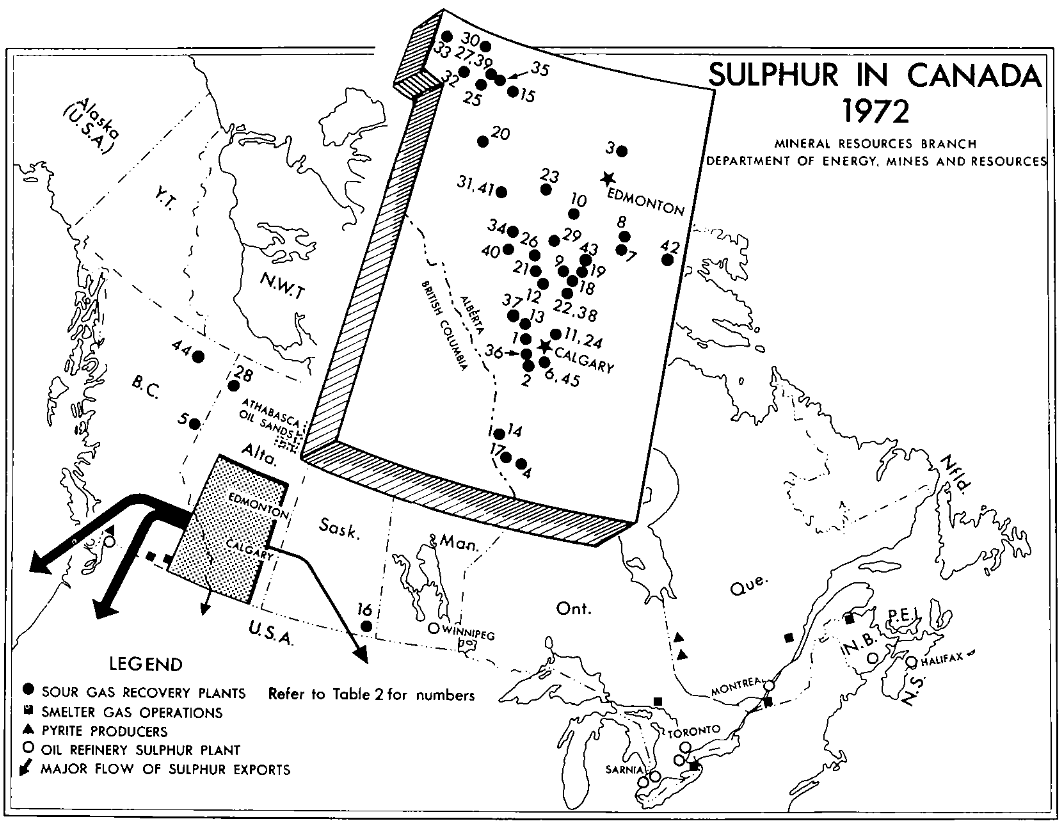
**Daily rated capacity, long tons.

Athabasca oil sands. The Athabasca oil sands constitute a vast deposit of relatively unconsolidated sandstone impregnated with bitumen, covering some 30,000 square miles of northeastern Alberta. The Alberta Oil and Gas Conservation Board estimates that oil reserves in place exceed 600 billion barrels. The bitumen averages 4.5 per cent by weight sulphur, thereby constituting an extremely large reserve of

Table 2. Canada, sour gas sulphur extraction plants, 1972

Operating Company	Source Field or Plant Location	H_2S in Raw Gas	Daily Capacity
	(Alberta, except where noted)	(%)	(long tons)
1. Shell Canada	Jumping Pound	3-5	420
2. Gulf Oil Canada	Turner Valley	4	35
3. Imperial Oil	Redwater	3	21
4. Gulf Oil Canada	Pincher Creek	10	675
5. Canadian Occidental	Taylor Flats, B.C.	3	320
6. Texas Gulf, Inc.	Okotoks	33	430
7. Gulf Oil Canada	Nevis	3-7	198
8. Chevron Standard[1]	Nevis	7	258
9. Shell Canada	Innisfail	14	115
10. Gulf Oil Canada	Rimbey	1-3	328
11. Petrogas Processing	Crossfield	31	1,970
12. Home Oil	Carstairs	1	42
13. Canadian Fina Oil	Wildcat Hills	4	137
14. Canadian Occidental	Savannah Creek	13	381
15. Texas Gulf, Inc.	Windfall	16	1,875
16. Steelman Gas	Steelman, Sask.	1	12
17. Shell Canada[1]	Waterton	18-25	2,975
18. Amerada Hess Corp.	Olds	11	600
19. Mobil Oil Canada	Wimborne	14	244
20. Hudson's Bay Oil and Gas	Edson	2	304
21. Canadian Superior Oil	Harmattan-Elkton	53	805
22. Hudson's Bay Oil and Gas	Lonepine Creek	10	201
23. CanDel Oil[1]	Minnehik-Buck Lake		32
24. Amoco Canada Petroleum	East Crossfield	34	1,480
25. Amoco Canada Petroleum	Bigstone Creek	19	320
26. Hudson's Bay Oil and Gas	Caroline	1	18
27. Hudson's Bay Oil and Gas	Kaybob South	17	1,044
28. Aquitaine Co. of Canada	Rainbow Lake	4	70
29. Hudson's Bay Oil and Gas	Hespero	1	11
30. Hudson's Bay Oil and Gas	Sturgeon Lake South	10	50
31. Hudson's Bay Oil and Gas	Brazeau River	1	59
32. Shell Canada[1]	Simonette River	15	90
33. Atlantic Richfield	Gold Creek		100
34. Gulf Oil Canada	Strachan	10	830
35. Hudson's Bay Oil and Gas	Kaybob South	17	1,066
36. Imperial Oil	Quirk Creek		286
37. Shell Canada	Burnt Timber Creek	8.5	190
38. Canadian Superior Oil	Lonepine Creek	12	145
39. Chevron Standard	Kaybob South	19	2,850
40. Aquitaine Co. of Canada[1]	Ram River	9-35	4,000
41. Tenneco Oil & Minerals	Brazeau River		40
42. Canadian Ind. Gas	Kessler		7
43. Imperial Oil[2]	Joffre		27
44. Westcoast Transmission	Ft. Nelson, B.C.		250
45. Sun Oil[2]	Black Diamond		13
Total daily rated capacity December 31, 1972			24,778

[1]Plants increased capacity in 1972. [2]New plants 1972.



sulphur. The Canadian Petroleum Association estimates recoverable reserves, using the existing oil sand extraction plant, at 40.8 million long tons of sulphur.

In late 1967, Great Canadian Oil Sands Limited (GCOS) completed the first commercial oil-sand extraction plant at a cost of $240 million. The ancillary sulphur recovery plant is designed to produce 300 long tons of sulphur daily. Operating problems which the plant has experienced since start-up have been alleviated following modifications and installation of new equipment. Sulphur production has consequently increased from 47,000 long tons in 1970 to 60,000 long tons in 1971. In December 1971, Syncrude Canada Ltd. obtained approval from the Alberta Energy Resources Conservation Board to increase the previously proposed production rate of 80,000 b/d to 130,500 b/d synthetic crude oil and products. This project is scheduled to start up in 1976 subject to confirmation from the provincial government, which is currently formulating policy on oil sands development. Annual recovery of sulphur from this plant should be about 185,000 long tons.

Oil refineries. Some crude oils contain as much as 5 per cent sulphur either as hydrogen sulphide or in other compounds. Domestic crudes generally contain less than 1 per cent sulphur. The sulphur may either be removed in the form of H_2S or treated to form nondeleterious disulphides. Recovery techniques employed during oil refining are similar to those used in the removal of sulphur from sour gas.

In Canada, sulphur is recovered from imported crudes at oil refineries in Nova Scotia, New Brunswick and Quebec. Output from these refineries was 61,000 long tons in 1972. Sulphur, recovered from domestic crudes at oil refineries near Toronto, Sarnia, Winnipeg, Edmonton and Vancouver, amounted to about 74,700 tons in 1972. More rigid regulations designed to, combat air pollution will undoubtedly result in increased sulphur recovery from this source in the years ahead. Refinery installations and expansions proposed to 1975 will increase capacity by about 15 per cent and total sulphur produced from Canadian oil refineries will exceed 150,000 long tons per year.

Coal. Coke oven gases generally contain some hydrogen sulphide, the quantity dependent upon the sulphur content of the coal being carbonized. Ordinarily, the H_2S is removed in 'iron oxide boxes' but it can also be recovered and converted to elemental sulphur.

Table 3. Proposed new plants and expansions for 1973 [1]

Operating Company	Location	Proposed Daily Rated Capacity
	(Alberta)	(long tons)
Gulf Oil Canada	Nevis	292
Ltd.	Strachan	916.5
Hudson's Bay Oil	Brazeau R.	89.3
and Gas Co. Ltd.	Sturgeon Lake South	96
Shell Canada	Simonette	209
Ltd.	Innisfail	158.1
Anticipated daily rated capacity end of 1973		25,197

[1]No new plants are scheduled. The above are all expansions.

A research agreement between the United States Department of the Interior and the American Gas Association was entered into in July 1971; $300 million will be spent over an eight-year period with the aim of developing an optimum process for the commercial production of high-quality, pollution-free gas from coal by 1980. This measure is being taken in the hope of meeting energy demands which are anticipated to outstrip growth of natural gas reserves in the United States. Large quantities of sulphur could ultimately be produced in coal gasification plants. Although coal in western Canada is low in sulphur (less than 0.5%), coal from the Maritimes is notably sulphurous. With more stringent pollution regulations coming into force, coal gasification may become the only way in which this energy source can be utilized in the future.

Metallic sulphide sources

In Canada, the use of metallic sulphides for their sulphur content dates back to 1866. Early operations consisted essentially of roasting pyrite for the direct manufacture of sulphuric acid. In the 1920's the use of base-metal smelter gases for the manufacture of byproduct H_2SO_4 began near Sudbury, Ontario, and at Trail, British Columbia. Virtually all Canada's sulphur production was from metallic sulphides prior to 1951 when the first sour gas sulphur recovery plant was built. In 1972, metallic sulphides provided 616,100 long tons of contained sulphur and accounted for only 8 per cent of Canada's total sulphur production.

Smelter gases. Effluent gas from smelting of sulphide ores contains from 1 to 12 per cent sulphur dioxide (SO_2). Recovery of the SO_2 includes processes for cleaning, purifying, cooling and concentrating. Concentrated SO_2 is then used directly for the manufacture of H_2SO_4 via the contact-acid process. Occasionally, the SO_2 is compressed to liquid sulphur dioxide and in some cases is used for the manufacture of oleum (fuming sulphuric acid, $H_2S_2O_7$).

For this review, sulphur in smelter gases includes sulphur values recovered from metallurgical SO_2 gases and converted directly to H_2SO_4, liquid SO_2 and oleum. These metallurgical works include base metal and iron ore recovery plants located in New Brunswick, Quebec, Ontario and British Columbia. Production in 1972 was 562,500 long tons of contained sulphur, an increase of 2 per cent from 1971.

The largest sulphuric acid plant complex in Canada is that of Canadian Industries Limited (CIL) at Copper Cliff, Ontario. The company operates three acid plants that have a combined daily capacity of 2,255 tons of H_2SO_4 based on SO_2 gas from The International Nickel Company of Canada, Limited's iron ore recovery plant. In addition, CIL operates a liquid sulphur dioxide plant at Inco's nearby Copper Cliff smelter. Much of the acid produced at Copper Cliff is shipped by unit-train about 475 miles to CIL's fertilizer works near Sarnia, Ontario. The company completed a new sulphuric acid depot and storage centre at Niagara Falls, Ontario, in 1972. The $1.5-million facility consists of a 60,000-ton storage tank with equipment for unloading unit-trains and loading tank-cars and trucks. Acid from Copper Cliff is shipped directly to the new facility via 56-car unit-trains.

Sulphuric acid is also produced from smelter gases by Belledune Acid Limited at Belledune, New Brunswick. This company, a subsidiary of Brunswick Mining and Smelting Corporation Limited, supplies acid to the adjacent plant of Belledune Fertilizer Limited, which is also a subsidiary of Brunswick.

Cominco Ltd. operates sulphuric acid plants at Kimberley and Trail, British Columbia, based on its pyrrhotite roaster and lead-zinc smelter, respectively. Combined capacity of these acid plants is in the order of 850,000 short tons of H_2SO_4 a year. Much of the acid produced is utilized by Cominco in the manufacture of fertilizers.

Aluminum Company of Canada, Limited, Allied Chemical Canada, Ltd., and Canadian Electrolytic Zinc Limited produce sulphuric acid from the roasting of zinc concentrates at Arvida and Valleyfield, Quebec.

The pyrrhotite roasting facility of Falconbridge Nickel Mines Limited, at Falconbridge, Ontario, and the associated elemental sulphur recovery unit of Allied Chemical closed in January 1973 after a year of operation plagued by technical problems.

Texas Gulf, Inc.'s new Timmins, Ontario zinc plant which started up in April 1972, has a sulphuric acid capacity of 230,000 short tons a year. Gaspé Copper Mines, Limited, a subsidiary of Noranda Mines Limited is expanding its facilities at Murdochville, Quebec,

Table 4. Canada, principal sulphur operations based on metallic sulphides, 1972

Operating Company	Plant Location	Raw Material	Annual Capacity 100% H_2SO_4	Annual Capacity Approx. S equiv.
			(short tons)	
Smelter Gases				
Belledune Acid	Belledune, N.B.	SO_2 lead-zinc	250,000	80,000
Alcan	Arvida, Que.	SO_2 zinc conc.	50,000	17,000
Allied Chemical	Valleyfield, Que.	SO_2 zinc conc.	160,000	53,000
Allied Chemical	Falconbridge, Ont.	SO_2 pyrrhotite	–	135,000[1]
Canadian Electrolytic Zinc	Valleyfield, Que.	SO_2 zinc conc.	135,000	45,000
Canadian Industries	Copper Cliff, Ont.	SO_2 pyrrhotite	750,000	250,000[2]
Cominco	Kimberley, B.C.	SO_2 pyrrhotite	360,000	120,000
Cominco	Trail, B.C.	SO_2 lead-zinc	490,000	160,000[2]
Texas Gulf	Timmins, Ont.	SO_2 zinc conc.	230,000	75,000
			Product	
Pyrite and Pyrrhotite				
Noranda Mines	Noranda, Que.	Sulphide ore	Pyrite concentrate	
Normetal Mines	Normetal, Que.	Sulphide ore	Pyrite concentrate	
Anaconda Canada	Britannia, B.C.	Sulphide ore	Pyrite concentrate	

[1]Sulphur in elemental form. [2]Includes sulphur content in liquid SO_2 production.
– Nil.

at a cost of $22 million. Sulphuric acid production will be about 500,000 short tons annually. Half will be used to leach low-grade oxide ore at the mine, some will be shipped to the Belledune, New Brunswick fertilizer plant and the remainder to other markets. The new facility is expected to be ready in 1973. Cominco Ltd. is examining the feasibility of a copper smelter possibly at Kimberley to treat concentrates from the Highland Valley in British Columbia. Such a facility would likely be capable of producing 500,000 short tons of H_2SO_4 per year.

Shipments of acid and oleum to the United States in 1972 were 34,031 tons contained sulphur. Small amounts were shipped elsewhere, mainly to the West Indies.

Pyrite and pyrrhotite. Pyrite and pyrrhotite concentrates produced as a byproduct of base metal mining operations are sometimes marketed for their sulphur content. The distinction between the category of sulphur in pyrite and pyrrhotite and that in smelter gases used in this review is based upon this concept. For example, although most of the acid production at Copper Cliff, Ontario, and Kimberley, British Columbia, is dependent upon the roasting of iron sulphides, the sulphur production is reported as smelter gases. In other instances, however, the iron sulphide concentrates are sold and shipped for roasting elsewhere, so this production is reported as pyrite and pyrrhotite.

Two companies – Noranda Mines Limited, and Normetal Mines Limited, – are engaged from time to time in shipping pyrite and pyrrhotite concentrates to pyrite roasters, principally in northeastern United States. Other companies are stockpiling pyrite concentrates pending development of future markets for this material. In 1972, Canada's pyrite and pyrrhotite shipments amounted to 116,000 long tons of concentrates (53,600 long tons contained sulphur) valued at $495,000. This tonnage is 60 per cent less than that of 1971, reflecting a falling trend associated with downward-moving sulphur prices which began in 1969. This source of sulphur is diminishing in world importance.

Canadian consumption and trade

Canadian consumption of sulphur as reported by consumers in all forms in 1972 amounted to an estimated 1.28 million long tons, of which elemental sulphur accounted for 56 per cent. Domestic consumption accounted for about one third of producers' shipments, clearly demonstrating that Canada is highly dependent upon export markets for sulphur sales. In addition to elemental sulphur from western Canada and pyrite concentrates, sulphuric acid and oleum are exported largely to the United States.

Canada is the world's largest supplier of elemental sulphur to world markets, exports in 1972 reaching 2.54 million long tons. This is an increase of 8 per cent after a slow previous year and represents a recovery to former growth levels. However, the value of 1972 production diminished to $19.8 million, a drop of 7 per cent as a consequence of further price deterioration. By comparison, the similar tonnage marketed in 1970 was valued to $43 million.

Because of its highly competitive nature, involuntary byproduct sulphur from western Canada has, over the years, penetrated much of the United States market. With falling prices and keen international competition, nine high-production-cost Frasch sulphur mines in the United States have been forced to close down since 1969. A bill introduced in 1970 by Senator Long (Louisiana) seeking to restrict sales of Canadian sulphur into the United States has thus far made little progress through Congress.

Freeport Minerals Company and Duval Corporation, following up on a statement made to the U.S. Tariff Commission in 1970 made further submissions in 1971 and early 1972 to the United States Bureau of Customs resulting in antidumping proceedings being launched against Mexico on February 5, 1972, and Canada on February 17, 1972. Subsequent hearings led to a dumping determination against Mexico based on export prices being lower than domestic prices. The Canadian case is as yet unresolved; a decision is required on whether a 'constructed cost of production', proposed by Duval, may be used as a measure of fair value in application of the Anti-dumping Act.

Because of these political pressures, as well as growing byproduct sulphur production in the United States, Canada's sales to this market dropped 15 per cent in 1971 and there was a further slight decline in 1972 to 893,912 long tons. Nonetheless, the United States remains the largest market for Canadian sulphur, accounting for one third of total exports.

Under highly competitive market conditions in Europe that favour Poland and the United States, Canada's exports to this major market area declined 33 per cent from the all-time high of almost 600,000 long tons in 1971. However, substantial gains were made in other markets, notably the Far East where sales increased 60 per cent over 1971. Much of the gain is attributable to sales to the People's Republic of China, which purchased 188,109 long tons from Canada. Other important gains included sales to Australia and Brazil.

World review

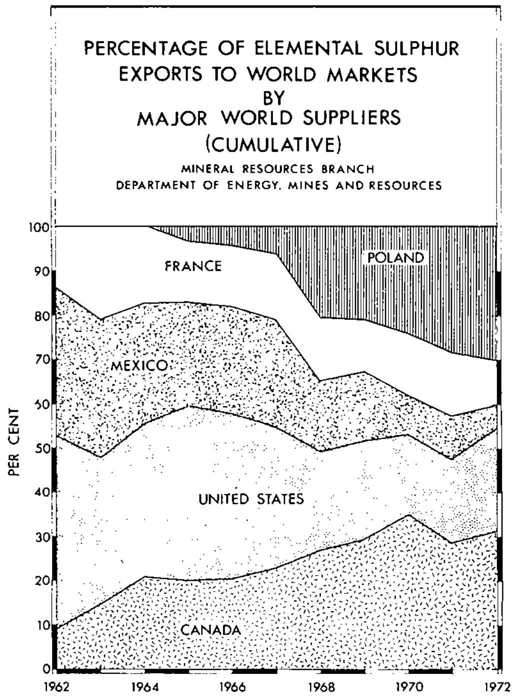
Although world sulphur production in 1972 exceeded demand for the fifth consecutive year, elemental sulphur consumption increased an estimated 10 per cent resulting in a reduction in all but Canada's stockpiles. The surge in demand – about twice the historical growth rate – is a result of renewed vigour in consuming industries, particularly the fertilizer industry augmented by further conversion of pyrite facilities to elemental sulphur burners.

In addition to strong demand and the removal of Canada's large stockpile from available supply at present prices, other factors contributed to an unexpected turn-around in sulphur supply-demand relationships. Sulphur recovery plants in Germany, the Middle East, Japan and the United States, which were due to reach capacity during 1972, experienced technical problems and other delays. The effect of even more stringent pollution abatement regulations, which were

Table 5. Canada, sulphur production and trade, 1963-72

	Production[1]				Imports	Exports	
	In Pyrites[3]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrites	Elemental Sulphur
				(long tons)		($)[2]	
1963	210,174	315,375	1,115,899	1,641,448	134,488	937,883	732,925
1964	154,617	395,910	1,596,474	2,147,001	133,534	878,545	1,155,807
1965	166,918	397,080	1,846,662	2,410,660	144,813	978,828	1,337,367
1966	144,901	446,702	1,822,676	2,414,279	129,871	981,000	1,249,113
1967	162,826	528,568	2,231,290	2,922,685	111,404	1,067,000	1,583,533
1968	139,136	594,935	2,304,090	3,038,161	67,688	1,056,000	1,884,821
1969	152,858	603,702	2,654,746	3,411,306	40,630	1,105,000	2,005,480
1970	156,707	630,206	3,167,931	3,954,844	47,725	1,226,000	2,668,072
1971	138,421	552,185	2,811,677	3,502,283	27,482	1,074,000	2,364,039
1972[p]	53,600	562,500	2,920,300	3,536,380	25,089	502,000	2,542,734

Source: Statistics Canada.
[1]See footnotes for Table 1. [2]Dollar value of pyrite exports, quantities not available. [3]Excludes pyrite used to make byproduct iron sinter beginning in 1961.
[p]Preliminary.



SOURCE: BRITISH SULPHUR CORPORATION TO 1970
MINERAL RESOURCES BRANCH ESTIMATE FOR 1971 AND 1972

expected to result in increased sulphur supplies, have, on the contrary, led to smelter shutdowns and hence reduced sulphuric acid capacity in Japan and the United States. The shortfall created by these conditions has tightened supply considerably and all output from France and Poland is reportedly sold out for 1973. This potential new capacity remains in the offing, however, and could in the near term have a major impact on sulphur markets.

Marked reductions in sulphur prices have caused transportation costs to assume greater importance in Canada's position as a competitor. Unit-train rates between Alberta and Vancouver are currently $6.40 per long ton, and handling and loading costs at the ocean terminal are around $2.50 per ton. A recently quoted figure for ocean freight from Vancouver to India is $10.50 per long ton, making total transportation costs from Alberta to this destination $19.40 per ton. By comparison, Polish transportation costs to India are about $9.70 per ton, a considerable advantage over Canada in spite of the higher costs of Frasch production; ocean freight from Iran to India is around $5 a ton. United States and Mexican transportation costs to Europe are about $7 a ton lower than Canadian costs and rates from Poland to this market are lower still. The expansion by Frasch producers of liquid sulphur shipments and liquid storage facilities, which reduce both handling costs and consumer plant costs (a saving of as much as $2 per ton), provides a further advantage to Canada's competitors.

Consumption of sulphur in the western world amounted to an estimated 32.0 million metric tons; western world sulphur production, in all forms, was about 33.5 million metric tons. Poland's production in 1972 exceeded 3.2 million metric tons and exports are estimated to have reached 2.4 million metric tons, of which about 1.9 million metric tons were delivered to western world markets. Polish production is obtained from two open pits and, by the Frasch method, from underground mines.

The world's largest producer of sulphur in all forms

Table 6. Canadian export markets 1972

Country of Area	Exports	Per Cent of Total
	(millions of long tons)	
United States	.89	35.1
Europe	.37	14.8
India	.19	7.7
Taiwan	.18	7.0
Australia	.28	11.2
New Zealand	.16	6.3
Korea	.09	3.5
Others	.37	14.4
Total	2.54	100.0

Table 7. Canada sulphur consumption, 1963-1972^p

	From Pyrites and Smelter Gases^e	Elemental Sulphur[1]	Total^e
	(long tons)		
1963	403,144	498,584	902,000
1964	433,551	486,033	920,000
1965	438,166	659,978	1,098,000
1966	461,478	725,053	1,187,000
1967	590,185	752,963	1,343,149
1968	669,763	741,155	1,410,919
1969	680,438	688,211	1,368,649
1970	682,992	751,543^r	1,434,535^r
1971	562,500	718,443	1,280,907
1972^p	562,500^e	714,000^e	1,277,000^e

Source: Statistics Canada.
[1] As reported by consumers.
^{e}Estimated by Mineral Resources Branch; ^{p}Preliminary; ^{r}Revised.

Table 8. Canada, consumption of elemental sulphur by industry

	1970	1971
	(long tons)	
Chemicals	225,578	
Pulp and paper	394,438	
Rubber products	3,533	
Fertilizers	103,415	
Foundry	3,528	
Other industries[1]	21,098	
Total	751,590	718,489

Source: Statistics Canada. Breakdown by Mineral Resources Branch.
[1]Includes production of titanium pigments, pharmaceuticals and medicinals, starch, soaps and detergents, explosives, food processing, sugar refining and other minor uses.

Table 9. Canada, sulphuric acid production, trade and apparent consumption 1963-72

	Production	Imports	Exports	Apparent Consumption
	(short tons – 100% acid)			
1963	1,790,000	5,634	37,316	1,758,318
1964	1,941,000	4,209	67,409	1,877,800
1965	2,165,000	3,075	57,113	2,110,962
1966	2,500,000	6,948	54,948	2,452,000
1967	2,749,279	3,626	84,280	2,668,625
1968	2,852,027	2,606	125,971	2,728,662
1969	2,396,535	60,746	103,386	2,353,895
1970	2,728,298	10,966	142,559	2,596,705
1971	2,933,000	4,952	101,094	2,836,858
1972[p]	3,030,000	70,112	104,227	2,995,885

Source: Statistics Canada.
[p]Preliminary.

is the United States, with the majority of production derived from Frasch mines located in the Gulf Coast area. These deposits, when first developed in the early 1900's, made large tonnages of low-cost sulphur available to world markets and established the United States as the world's foremost supplier of elemental sulphur. United States shipments of Frasch sulphur in 1972 increased 13 per cent over 1971, requiring a withdrawal of over 350,000 long tons from stocks in addition to the 7.3 million tons produced. Recovered sulphur production and shipments increased 14.5 per cent giving combined elemental sulphur shipments of

Table 10. Canada, available data on consumption of sulphuric acid by industry, 1970

	(short tons– 100% acid)
Iron and steel mills	56,361
Other iron and steel	11,414
Electrical products	10,297
Leather tanneries	2,693
Pulp and paper mills	110,650
Processing of uranium ore	83,476
Manufacture of mixed fertilizers[1]	51,680
Manufacture of plastics and synthetic resins	26,543
Manufacture of soaps and cleaning compounds	18,771
Other chemical industries	69,520
Manufacture of industrial chemicals[2]	1,674,977
Petroleum refining	35,085
Mining[3]	50,000[e]
Nonferrous smelting and refining	268,227
Miscellaneous[4]	20,784
Total accounted for	2,490,478

Source: Statistics Canada.
[1]Includes consumption for production of superphosphate in this industry. [2]Includes consumption of 'own make' or captive acid by firms, classified to these industries. [3]Includes metal mines, nonmetal mines, mineral fuels and structural materials. [4]Includes synthetic textiles, explosives and ammunition and other petroleum and coal products, mineral wool, starch and glucose, vegetable oils, sugar refining and textile drying and finishing.
[e]Estimated.

9.46 million long tons in 1972. This reversed a declining trend which began in 1969. Exports increased 21 per cent to 1.85 million long tons, imports decreased 12 per cent and apparent domestic consumption increased 8 per cent. Despite rekindled demand, however, prices fell for the fourth consecutive year forcing closure of Jefferson Lake Sulphur's Hermitage mine in March 1972, bringing the total mine shutdowns to nine since 1969.

Mexico exported an estimated 440,000 long tons in 1972, down 35 per cent from the previous year. This precipitous drop is attributable to a reduction of about 200,000 long tons in shipments to the United States following dumping charges laid in February 1972 against Mexican producers. Offshore markets were also eroded somewhat as a result of increased sales by Poland and the United States.

Production of elemental sulphur from sour natural gas from the Lacq field in France was marginally lower than that of 1971. Exports declined 16 per cent and imports rose about 6 per cent in response to increased domestic demand during 1972.

Following technical and economic feasibility

Table 11. World production of sulphur in all forms, 1971

	Elemental	Other[1]	Total
	(thousands of metric tons)		
United States	8,772	1,610	10,382
U.S.S.R.	2,180	5,000	7,180
Canada	4,727	810	5,537
Poland	2,778	236	3,014
Japan	404	2,341	2,745
France	1,816	203	2,019
Spain	7	1,321	1,328
Mexico	1,178	40	1,218
Italy	82	863	945
West Germany	205	573	778
Iran	495	5	500
Finland	101	347	448
Norway	3	399	402
East Germany	115	260	375
Sweden	6	354	360
Others	904	4,476	5,380
Total	23,773	18,838	42,611

Source: British Sulphur Corporation, May/June 1972.
[1]Sulphur in other forms includes sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases mostly in the form of sulphuric acid.

studies into potential large tonnage uses for sulphur – a project initiated by the National Research Council – the Sulphur Development Institute of Canada (SUDIC) was formed in February 1973. Its purpose is to promote research and development of new uses, monitor current research, fund approved projects, and to liaise with other institutions elsewhere in the world where research is being carried on. New uses investigated over the last few years which show promise include: an asphalt-sand-sulphur mixture for road and airstrip paving, sulphur cement and other construction materials, pipeline insulation, etc. The Canadian initiative was followed by a similar project undertaken by the United States Bureau of Mines. Sulphur utilization was also added to the agenda of the International Review Group convened by Canada.

Outlook

Involuntary Canadian elemental sulphur, recovered from sour natural gas in western Canada, is one of the world's largest sources of abundant low-cost material and has, within the past decade, substantially altered the pattern of international sulphur supply. In 1960 Canada accounted for only 3.4 per cent of the world export market. In 1968, with a market share of 27.4 per cent, Canada became the world's largest exporter.

In 1972 export sales reached record levels, rebounding from a decline in 1971. World demand for sulphur in all forms surged over 7 per cent above the 1971 level echoing strong growth in fertilizers and general recovery in other consuming sectors. These trends are expected to continue during the near term. Fertilizers, under the stimulus of world food shortages and the expansion of modern agricultural practice in Asia, Africa and Latin America should sustain annual sulphur consumption growth in the 6-7 per cent range throughout the present decade. The People's Republic of China entered the sulphur scene as a buyer during 1972 and indications are that it will become a major market. Industrial development in these areas will add further to sulphur demand. The focus by government and industry on new uses for sulphur indicate that by the end of the decade, large-volume new uses for this commodity could be a reality.

Canadian sales for 1973 are expected to reach 3.5 million long tons. Further expansion in export sales after 1973 is predicated on the development of adequate storage facilities at the west coast, a problem which is recognized by the industry.

Production in 1973 will reach 7.2 million long tons and the inventory by year-end will top 12 million long tons. However, sulphur production growth rates will level off until after 1976 when extensive additional sour gas reserves, recently discovered in the Ricinus area, could be developed.

Many new suppliers, notably the Middle East and Venezuela will share more prominently in the market and pollution abatement will grow in importance.

Frasch producers in the United States improved sales considerably in 1972. In spite of this showing and the favourable outlook for sulphur, a new restraint is beginning to exert pressure on the industry. Ironically, the natural gas industry, which has become the Frasch industry's principal competitor in sulphur production, supplies the essential fuel – natural gas – for production of sulphur by the Frasch process. Energy shortages over the past year resulting in manufacturing plant and school shutdowns during the winter months focussed considerable attention on current usage of natural gas. Texas Gulf's mine at Bullycamp, Louisiana, which was closed down because gas supplies were reduced by the Federal Power Commission, resumed operations after a successful appeal. This operation's contract called for up to 10 million cubic feet per day. The entire Frasch industry of the United States uses some 50 billion cubic feet per year.

French production has reached a plateau and will likely decline slowly during the 1980's.

Under the influence of the foregoing factors, inventories will mount at a slower rate – virtually all in Canada – and production and consumption will tend toward a balance, perhaps reaching that point by the middle of the next decade.

Prices

Prices declined for the fourth straight year. The pattern by months was a fluctuating one and an average of $5.71 per long ton fob Alberta plant was obtained. A firming trend was predicted by many observers during the last months of 1972 and in January 1973, domestic price increases of $3 per long ton were announced by the major United States producers. Canadian Occidental Petroleum Ltd. followed and others are expected to do so as well.

Modest price increases in offshore markets are expected for 1973. Under the influence of buoyant sulphur markets, the trend of firming prices seems likely to continue over the next few years at least.

Canadian sulphur prices in 1972 quoted in Canadian Chemical Processing

	($)
Sulphur, elemental, fob works,	
contract, carload, per long ton	
January–July 1972	7.50 – 9.00
Sulphuric acid, fob plants, east,	
66° Be, tanks, per short ton	
December	31

United States prices in U.S. currency, quoted in Engineering and Mining Journal, December 1972

	($)
Sulphur, elemental	
U.S. producers, term contracts	
fob vessel at Gulf ports,	
La. and Tex., per long ton (nominal)	
Bright	25
Dark	26
Export prices, fob Gulf ports	
Bright	26
Dark	25
Mexican export fob vessel	
per long ton	
Bright	26
Dark	25

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92503-1	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur	free	free	free
92802-1	Sulphur, sublimed or precipitated, colloidal sulphur	free	free	free
92807-1	Sulphur dioxide	free	free	free
92808-1	Sulphuric acid, oleum	10%	15%	25%
92813-4	Sulphur trioxide	free	free	free

United States

Item No.		
418.90	Pyrites	free
415.45	Sulphur, elemental	free
416.35	Sulphuric acid	free

Item No.		(%)
422.94	Sulphur dioxide	
	On and after Jan. 1, 1970	8.5
	On and after Jan. 1, 1971	7
	On and after Jan. 1, 1972	6

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Talc, Soapstone and Pyrophyllite

G.H.K. PEARSE

Talc is a hydrous magnesium silicate $H_2Mg_3(SiO_3)_4$ formed by the alteration of rocks rich in magnesia (most commonly ultrabasic igneous rocks and sedimentary dolomite) within which it occurs as veinlets, tabular bodies, or irregular lenses. It is a soft flaky mineral with a greasy feel or 'slip'; it is readily ground to a fine white or nearly white powder, has a high fusion point, low thermal and electrical conductivity and is relatively chemically inert. Most of the uses of talc depend on individual physical properties or combinations of these properties.

Talc is produced in various grades which are usually classified by end use, such as cosmetic grade, ceramic grade, pharmaceutical grade and paint grade. A special high-quality block talc used in making ceramic insulators and other worked shapes is designated steatite grade.

Soapstone is an impure talcose rock generally occurring in massive, compact deposits from which blocks can be sawn. Soapstone has been used since early times in many parts of the world for carving ornaments, pipes, cookware, lamps and other utensils, an art which has survived among the Eskimos up to the present era. Present uses include metalworker's crayons, refractory bricks, and blocks for sculpturing.

Pyrophyllite is a hydrous aluminum silicate $H_2Al_2(SiO_3)_4$ formed by hydrothermal alteration of acid igneous rocks, predominantly lavas which are andesitic to rhyolitic in composition. It resembles talc in physical properties and for this reason finds uses similar to talc – notably in ceramic bodies and as a filler in paints, rubber and other commodities.

In Canada talc is produced in two provinces, Quebec and Ontario; pyrophyllite is produced only in Newfoundland. In 1972 the value of talc and soapstone shipments increased to $975,000 from $666,761 in 1971. The value of pyrophyllite production increased from $393,375 in 1971, to $560,000 in 1972.

Production and developments in Canada

Talc, soapstone. The earliest recorded talc production in Canada was in 1871-72 when 300 tons valued at $1,800 were shipped from a deposit in Bolton Township, southern Quebec by Slack and Whitney. In 1896 a deposit in Huntingdon Township, in the Madoc district in Ontario was opened up and over the next few years numerous deposits in this area were discovered and mined intermittently.

Several deposits in southern British Columbia and one in southwestern Alberta were discovered prior to 1920 and some of these were worked in a small way. At present, talc is mined by three companies, two in Quebec and one in Ontario. Total talc and soapstone production in Canada in 1972 reached an estimated 43,000 tons.

Baker Talc Limited produces talc and soapstone from an underground mine in South Bolton, Quebec, 60 miles southeast of Montreal. Ore from the mine is trucked 10 miles south to the company's mill facilities at Highwater. In former years, Baker Talc has produced a relatively low-grade, low-cost product suitable for use primarily as a dry-wall joint filler, asphalt filler and dusting compounds for asphalt roofing. Tests conducted in 1967-68, employing a Jones High Intensity Wet Magnetic Separator, were successful in upgrading talc products for use in the paint, cosmetic and paper industries and this process was added to the mill circuit in 1969. This project was supported by the federal Department of Industry Trade and Commerce. Throughout 1970 the new beneficiation circuit was tuned and modifications were made, including the addition of more flotation capacity and a thickener. Trial shipments of upgraded talc were made in 1970-71 for assessment in pulp and paper manufacture. The product proved satisfactory and regular shipments began in 1971. In 1972, seven paper mills were using the upgraded product and others are expected to place orders. Minor shipments have also been made for use as a filler in plastics and paints.

Along with talc output, the company from time to time markets soapstone blocks as an artistic medium to schools and art shops.

Broughton Soapstone & Quarry Company, Limited quarries talc and soapstone from deposits near Broughton Station in the Eastern Townships of Quebec, where the same geological conditions are evident as in the South Bolton area. Several low-priced grades of ground talc are produced and soapstone is sawn to produce metalworker's crayons and blocks for sculpturing.

Canada Talc Industries Limited produces talc from underground workings at Madoc, Ontario. The deposits at Madoc are extensive and were formed by the alteration of dolomitic marble. Impurities in the deposit consist of tremolite and dolomite, which limit the use of some ground products. A high-quality

Table 1. Talc, soapstone and pyrophyllite production, trade and consumption, 1971-72

	1971		1972^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Talc and soapstone				
Quebec[1]	..	314,220	..	490,000
Ontario[2]	..	352,541	..	485,000
Total	..	666,761	..	975,000
Pyrophyllite				
Newfoundland	..	393,375	..	560,000
Total production	65,562	1,060,136	80,000	1,535,000
Imports (talc)				
United States	33,428	1,821,000	39,206	2,069,000
Italy	323	22,000	1,277	50,000
Other countries	1	...	22	2,000
Total	33,752	1,843,000	40,505	2,121,000
	1970		1971^p	
Consumption[3] (ground talc, available data)				
Ceramic products	8,505		6,190	
Paints and wall joint sealers	7,156		7,469	
Roofing	6,593		6,412	
Paper and paper products	3,699		4,157	
Rubber	1,682		2,629	
Insecticides	682		266	
Toilet preparations	843		666	
Cleaning compounds	734		645	
Pharmaceutical preparations	227		163	
Linoleum and tile	646		1,474	
Other products[4]	5,378^r		8,587	
Total	36,145^r		38,658	

Source: Statistics Canada.
[1]Ground talc, soapstone, blocks and crayons; [2]Ground talc; [3]Breakdown by Mineral Resources Branch; [4]Chemicals, foundries, gypsum products and other miscellaneous uses.
^p Preliminary; .. Not available; ... Less than $1,000; ^r Revised.

product suitable as a filler material in the paint industry is produced.

Numerous deposits of talc and soapstone occur in other parts of Canada. A soapstone deposit on Pipestone Lake in Saskatchewan was worked by Indians for the manufacture of pipes and various utensils. Reserves are reported to be considerable. In the Northwest Territories, a few occurrences of soapstone are known, from which Eskimos obtained material for carving. Showings of minor importance occur at several localities in Nova Scotia and Newfoundland.

Pyrophyllite. Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc. produces pyrophyllite from an open-pit mine near Manuels, 12 miles southwest of St. John's, Newfoundland. Ore is crushed, sized and hand-cobbed at the mine site prior to trucking a short distance to tidewater. Continuous chemical analyses and physical tests are run on all material delivered from the mine to the loading dock. Blended ore is shipped in bulk to the parent company's operation at Lansdale, Pennsylvania, where it is used in the manufacture of ceramic tile. After a slow year in 1971, pyrophyllite production recovered in 1972 to former levels. Annual production is estimated to be about 37,000 tons. The pyrophyllite deposit at Manuels appears to be a hydrothermal alteration of sheared rhyolite. Altered zones are

Table 2. Production and trade, 1963-72

	Production[1]			
	Talc and Soapstone	Pyrophyllite[2]	Total[3]	Imports, Talc
	(short tons)			
1963	22,467	31,783	54,250	27,539
1964	25,316	32,816	58,132	31,598
1965	22,703	30,134	52,837	27,858
1966	29,596	40,548	70,144	24,918
1967	..	..	60,665	26,482
1968	..	..	80,589	28,244
1969	..	..	75,850	34,910
1970	..	..	72,055	33,068
1971	..	..	65,562	33,752
1972^p	..	..	80,000	40,505

Source: Statistics Canada.
[1] Producers' shipments; [2] Producers' shipments of pyrophyllite, all exported; [3] From 1967, breakdown of producers' shipments not available for publication.
^{p}Preliminary; .. Not available.

associated for the most part with extensive fracturing near intrusive granite contacts. Reserves are extensive.

Other known pyrophyllite deposits in Canada include: an extensive area of impure pyrophyllite near Stroud's Pond in the southern part of Burin Peninsula, Newfoundland, a deposit near Ashcroft, British Columbia and three deposits in the Kyuquot Sound area, 200 miles northwest of Victoria, British Columbia. The Vancouver Island deposits were worked on a limited scale in the early part of this century.

Trade and markets

Most talc and soapstone produced in Canada is consumed domestically while all pyrophyllite produced is exported. Imported talc, most of it from the United States, is high-quality, high-value material suitable for use in the paint, ceramics, paper and cosmetic industries. Production of these superior grades of talc in Canada began in 1970 with the new beneficiation techniques incorporated into Baker Talc's mill and in 1971 a product acceptable to the pulp and paper industry was marketed. It is anticipated that imported high-quality talc will soon be displaced to some extent in other industries by this domestic product. Imports in 1972 amounted to 40,505 tons valued at $2,121,000. Of this, 39,206 tons were imported from the United States and the remainder predominantly from Italy. Average value of imports in 1972 was $52 a ton while domestic production sells in the range of $10-70 a ton, depending upon quality.

Uses

Talc is used mostly in a fine-ground state although soapstone is used in massive or block form. There are many industrial applications for ground talc but major consumption is limited to less than a dozen industries.

Talc is used as a filler material in the manufacture of high-quality paper where it aids in dehydration of the pulp, improves sizing characteristics, reduces the tendency of papers to yellow and assures a well bonded surface to promote ease of printing. For use in the paper industry talc must be free of chemically active compounds such as carbonates, iron minerals, manganese, etc., have a high reflectance, possess high retention characteristics in the pulp and be free of abrasive impurities. Micronized material provides a high-gloss finish on coated papers.

The ceramic industry utilizes very finely ground talc which increases the translucence and toughness of the finished product and aids in promoting crack-free glazing. For use in ceramics, talc must be low in iron, manganese and other impurities which would discolour the fired product.

High-quality talc is used as an extender pigment in paints. Specifications for a talc pigment, as established in ASTM Designation D605-69, relate to the chemical composition, colour, particle size, oil absorption and

Table 3. World production of talc, soapstone and pyrophyllite, 1970-72

	1970	1971^p	1972^e
	(short tons)		
Japan	2,066,230	2,089,474	2,100,000
United States	1,027,929	1,037,297	1,082,000
U.S.S.R.	419,000	441,000	..
France	256,838	250,000	250,000
South Korea	224,952	234,185	..
India	185,641	195,477	..
People's Republic of China	165,000	165,000	..
Italy	170,657	152,936	150,000
Finland	69,140	110,979	..
Austria	110,406	100,995	100,000
North Korea	88,000	99,000	..
Norway	70,500	70,500	70,000
Canada	72,055	65,562	..
Romania	62,532	65,000	..
Australia	141,253	60,000	..
Other countries	256,886	253,267	1,750,000
Total	5,387,019	5,390,672	5,502,000

Sources: U.S. Bureau of Mines, *Minerals Yearbook*, Preprint 1971; U.S. Bureau of Mines, Commodity Data Summaries, January 1973; Statistics Canada.
^{p}Preliminary; ^{e}Estimate; .. Not available.

consistency of, and dispersion in, a talc-vehicle system. A low content of carbonates, a nearly white colour, a fine particle size with controlled particle size distribution and a specific oil-absorption are important. However, because of the variety of paints, precise specifications for talc pigments are generally based on agreement between consumer and supplier. Paint characteristics influenced by the use of talc as an extender are gloss, adhesion, flow, hardness and hiding power.

Talc is well known for its use in pharmaceutical preparations and cosmetics. It is the major ingredient in face, baby and body powders. Finely ground, high-purity material is used as a filler in tablets and as an additive in medical pastes, creams and soaps. Material used for these purposes should be free of deleterious chemical compounds, abrasive impurities and fibrous minerals such as tremolite and asbestos, which are believed to be injurious to health when inhaled or ingested.

Lower-grade talc is used as a dusting agent for asphalt roofing and gypsum board; as a filler in dry-wall sealing compounds; as a filler material in floor tiles; in asphalt pipeline enamels; in auto-body patching compounds; as a carrier for insecticides and as a filler or dusting compound in the manufacture of rubber products.

Other applications for talc include use in cleaning compounds, polishes, electrical cable coating, plastic products, foundry facings, adhesives, linoleum, textiles, and in the food industry.

Particle-size specifications for most uses require the talc to be minus 325 mesh. The paint industry demands from 99.8 to 100 per cent minus 325 mesh. For rubber, ceramics, insecticides and pipeline enamels, 95 per cent minus 325 mesh is usual. In the wall-tile industry 90 per cent minus 325 mesh is generally required. For roofing grades the specification is about minus 80 mesh with a maximum of 30 to 40 per cent minus 200 mesh.

Soapstone has now only very limited use as a refractory brick or block, but because of its softness and resistance to heat it is still used by metalworkers for marking crayons. The ease with which it can be carved makes it an excellent artistic medium.

Pyrophyllite can be ground and used in much the same way as talc but at present the use of the Canadian material is confined to ceramic tile. It must be minus 325 mesh and contain a minimum of quartz and sericite, which are common impurities.

World review

Deposits of talc are widely distributed throughout the world, but have been commercially developed only in the more industrialized countries. Because talc is of relatively low unit value, only a very small proportion of world production is traded internationally. The majority of international trade takes place within Europe, in the Far East between Japan, the People's Republic of China and Korea, and in North America between Canada and the United States. However, talc of exceptional purity is able to withstand the cost of transportation over much greater distances. For example, high-grade French, Italian, Indian and Chinese talcs are shipped throughout the world.

Prices

United States talc prices according to Oil, Paint and Drug Reporter, December 25, 1972

	($ per ton)		($ per ton)
Canadian		California	
Ground, bags, carlot, fob mines	20-35	Domestic, ordinary, off-colour, bags, carlot fob works	34-39.50
Vermont		New York	
Domestic, ordinary, off-colour, ground, bags, carlot, fob works	22.25	Domestic, fibrous, ground, bags	35.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
71100-3	Talc or soapstone	10	15	25
71100-8	Micronized talc	free	5	25
29655-1	Pyrophyllite	free	free	25
29645-1	Talc for use in manufacturing of ceramic tile (expires Feb. 28, 1974)	free	free	25
29646-1	Talc for use in manufacture of pottery (expires Feb. 28, 1974)	free	free	25

Tariffs (concl'd)

United States
Talc, steatite, soapstone

Item No.		On and After January 1 1971	1972
523.31	Crude and not ground	0.02¢ per lb	
523.33	Ground, washed, powdered, or pulverized	7%	6%
523.35	Cut or sawed, or in blanks, crayons, cubes, disks, or other forms	0.2¢ per lb	0.2¢ per lb
523.37	All other, not provided for	14%	12%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Tin

G.S. BARRY

Canada is an important consumer but small producer of tin. The only producer is Cominco Ltd., which recovers cassiterite (SnO_2) as a byproduct from milling lead-zinc ores at Kimberley, British Columbia. The concentrate is exported to Britain and the United States for smelting. In addition, Cominco obtains a lead-tin alloy from the treatment of lead bullion dross in the indium circuit of the Trail smelter in British Columbia. The company also produces, from purchased commercial-grade metal, small quantities of Tadanac brand high-purity tin (99.9999 per cent) and special research-grade (99.999 per cent).

Canadian production in 1972 of tin in tin concentrate and lead-tin alloy was 163.7 tons* valued at $657,000.

Canadian industrial requirements of tin are met mainly by imports that in 1972 totalled 5,906 tons valued at $21,545,000. In addition M & T Products of Canada Limited, Hamilton, Ontario, recovers a secondary tin product by de-tinning scrap. The product is potassium stannate used mainly in electroplating applications. An equivalent of some 125 to 150 tons of tin annually is thus recovered. Canada also imports tinplate and exports tin metal, tin metal scrap and tinplate scrap mainly to the United States. In 1972, 67 per cent of Canadian metal imports came from Malaysia, mainly as high-quality Straits brand, 11 per cent from the United States and 5 per cent from Thailand. Canada also imported, for the first time in many years, 575 tons or 10 per cent of its requirements, directly from the People's Republic of China. The statistical summary in Table 2 indicates that in 1972 substantial additional supplies must have gone to stocks.

Brunswick Tin Mines Limited, a subsidiary of Sullivan Mining Group Ltd., continued exploration and metallurgical testing on its multimineral deposit in southwestern New Brunswick. Revised reserves for the Fire Tower Zone reported in September 1972 are 29.5 million tons with an average grade of 0.20% tungsten, 0.09% molybdenum, 0.08% bismuth, 0.04% tin, 0.07% copper, 0.35% zinc, 0.08% lead, 4% fluorspar and about one ounce of indium per ton. A better promise for a viable tin deposit, however, is given by indications that the North Zone, one mile north of the Fire Tower deposit, may contain several million tons of a mineralized porphyritic intrusive grading better than 0.5% tin and values in tungsten. As of January 1973 drilling was still in progress on this deposit and early indications are that results are continuing to be very encouraging.

Fine-grained cassiterite is a mineralogical component of sulphide ores of several Canadian mines but cannot be economically recovered except at the Sullivan mine of Cominco and in the future at Ecstall Mining Limited's mine near Timmins. Ore grades at these mines are between 0.15 and 0.25 per cent SnO_2. Tin is present in small quantities in the zinc-lead orebodies of Brunswick Mining and Smelting Corporation Limited, New Brunswick and in the South Bay mine, Ontario, of Selco Mining Corporation Limited. Late in 1972 Ecstall Mining Limited, a subsidiary of Texas Gulf, Inc., began construction of a tin-circuit at its base metals concentrator at Timmins. The capital cost of this installation is estimated at $5.5 million. Production is scheduled to commence in December 1973 at an annual rate of approximately 1,500,000 pounds or slightly more of contained tin. Concentrates are expected to average 54 per cent tin; they will be sold to U.S. or European smelters.

The principal use of tin in Canada, accounting for over 50 per cent of the total consumption, is in the production of tinplate. There are two producers: Dominion Foundries and Steel, Limited (Dofasco) and The Steel Company of Canada, Limited (Stelco), both at Hamilton, Ontario. Canadian output of tinplate is all electrolytic; hot-dip production ceased in 1966. It is estimated that approximately 2,650 tons of tin were consumed in 1972 for a production of some 500,000 tons of tinplate, about the same as last year.

Dofasco and Stelco each operate three electrolytic tinplate lines. Stelco's third line, with a capacity of 175,000 tons of tinplate a year was commissioned in November 1971. It can be converted to produce steel with other types of coatings, notably chrome-coated steel. Dofasco's third line is also dual purpose, and was commissioned in March 1972. It doubled the company's tinplate manufacturing capacity.

The second largest use for tin is in the manufacturing of solders. Between 1,500 and 1,900 tons of tin are used annually for this product, considerably more than officially reported in statistics. Important Canadian users of unmanufactured tin for this application are The Canada Metal Company, Limited,

* Metric tons of 2,205 pounds are used throughout this and the 1971 review in contrast to long tons of 2,240 pounds used in reviews of preceding years.

Table 1. Canada, tin production, imports and consumption 1971-72

	1971		1972^p	
	(metric tons)	($)	(metric tons)	($)
Production				
Tin content of tin concentrates and lead-tin alloys	144	421,079	164	657,000
Imports				
Blocks, pigs, bars				
Malaysia	3,183	11,400,000	3,966	14,400,000
United States	779	2,853,000	621	2,336,000
People's Republic of China	–	–	575	2,086,000
Thailand	385	1,400,000	300	1,106,000
Australia	35	127,000	165	590,000
Nigeria	513	1,808,000	105	370,000
Britain	111	389,000	89	317,000
Other countries	97	398,000	85	340,000
Total	5,103	18,375,000	5,906	21,545,000
Tinplate				
United States	2,242	529,000	1,709	481,000
Britain	177	53,000	204	87,000
Other countries	2	2,000	–	–
Total	2,421	584,000	1,913	568,000
Tin, fabricated materials, not elsewhere specified				
United States	25	109,000	42	122,000
Britain	...	1,000	1	3,000
Total	25	110,000	43	125,000
Exports				
Tin in ores and concentrates, and scrap				
Britain	34	87,000	91	161,000
United States	45	98,000	51	49,000
Mexico	137	275,000	–	–
Total	216	460,000	142	210,000
Tinplate scrap				
United States	21,474	592,000	12,761	377,000
Consumption				
Tinplate and tinning	2,549		2,624	
Solder	1,024^r		1,594	
Babbitt	146^r		166	
Bronze	170		194	
Galvanizing	10		6	
Other uses (including collapsible containers, foil)	75^r		80	
Total	3,974^r		4,664	

Source: Statistics Canada
^{p} Preliminary; – Nil; .. Not available; ... Less than 1 ton; ^{r}Revised.

Federated Genco Limited, Kester Solder Company of Canada Limited, Toronto Refiners and Smelters Limited, Tonolli Company of Canada Ltd., Metals & Alloys Company Limited, and Cramco Alloy Sales Limited. Bronze is also produced in Canada, chiefly by The Noranda Copper Mills Limited and Anaconda Canada Limited.

World developments

Tin is the only metal for which there is formal co-operation between producer and consumer interests and among governments to modify problems of price and demand. The large mine producers of tin are developing countries with little consumption and the largest consumers are the major industrial countries. A common interest in market stability in the postwar period led first to a study group and then to the First International Tin Agreement in 1956 under the auspices of the United Nations. The tin industry is characterized by low consumption growth rate and until recently a widely fluctuating price for the metal.

The first International Tin Agreement was in force from July 1, 1956 to June 30, 1961 and the Second from July 1, 1961 to June 30, 1966. The Third and Fourth International Tin Agreement came in force, respectively, on July 1, 1966 and on July 1, 1971. The main objective of The International Tin Council is the consideration of short-term problems of supply and demand and pricing. Decisions that affect supply and price, however, are made with regard to long-term trends. Consumer and producer members have an equal number of votes in the governing body, The International Tin Council. Canada is a signatory to the Agreement and, in proportion to its consumption, has 41 out of the total of 1,000 votes allocated to consumers. The 19 consumer members in 1972 accounted for 60 per cent of total consumption. The United States is the main nonmember country among western consuming countries (44,200 tons for 10 months of 1972). The total does not include U.S.S.R. consumption, as its data is not available.

Producer members are Australia, Bolivia, Indonesia, Malaysia, Nigeria, Thailand and The Republic of Zaïre. Counted together, producer and consumer members of the Council account for 93 per cent of the noncommunist production of tin in concentrate, of which the seven producer members account for 90 per cent.

Members contributed cash or metal to establish a buffer stock. The operation of the stock to which until recently only producer members contributed, is vested in a manager appointed by the Tin Council. The ranges of permissible prices are set by the Tin Council and within this framework the manager of the buffer stock may use discretionary judgment to buy or sell tin metal, but not concentrates, on major markets to modify price fluctuations. Council may impose export controls to curtail metal supply if tin in the buffer stock and other conditions appear to warrant such action.

The Fourth Agreement, embodying the objectives and control mechanisms of the Third Agreement, came into force on July 1, 1971 with the following changes in membership: Australia became a producer member, having been a consumer member, and West Germany and the U.S.S.R. joined as new consumer members in 1971, China (Taiwan) withdrew in 1972 and Romania joined in January 1973. Financial resources of the buffer stock, until recently wholly the responsibility of the producer members, were significantly bolstered by voluntary contributions from the Netherlands since 1971 and France since 1973 in proportion to their consumption and votes on the Council.

The principal change is that the Buffer Stock Manager under the Fourth Agreement has the authority to both buy and sell in the upper and lower price sectors, which is expected to make buffer stock operations more flexible. Another change, not part of the terms of the Agreement, is that the International

Table 2. Canada, tin production, exports, imports and consumption, 1962-72

	Production[1]	Exports[2]	Imports[3]	Consumption[3] Recorded	Consumption[3] Unrecorded[e]
	(metric tons)				
1962	296	292	2,310	4,579	
1963	421	813	4,260	5,021	
1964	160	334	4,927	4,899	
1965	171	219	5,073	4,910	
1966	322	342	4,322	5,052	
1967	198	331	4,621	4,889	
1968	163	119	4,369	4,319	
1969	131	313[er]	5,024	4,349	450
1970	120	272[er]	5,111	4,554	500
1971	144	296[er]	5,104	3,974[r]	800
1972[p]	164	379[e]	5,906	4,664	450

Source: Statistics Canada, and Mineral Resources Branch data.
[1]Tin content of tin concentrates shipped, plus tin content of lead-tin alloys produced. [2]Tin in ores and concentrates and tin scrap; for 1969 to 1972, includes an estimate of metal exports. [3]Tin metal.
[p]Preliminary; . . Not available; [r]Revised; [e]Estimate.

Table 3. Estimated world[1] production of tin-in-concentrates, 1962, 1971-72.

	1962	1971	1972
	(metric tons)		
Malaysia	59,543	75,445	76,830
Bolivia	22,150	30,290	32,850
Thailand	14,915	21,689	22,066
Indonesia	17,588	19,767	21,766
Australia	2,758	9,433	12,081
Nigeria	8,342	7,326	6,731
Zaïre	7,312	6,500	6,500
Total, including countries not listed	143,771	186,800	197,500

Source: International Tin Council, Statistical Bulletin for 1962-71.
[1]Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary; it should be noted that China (People's Republic) and U.S.S.R. are large tin producers.

Monetary Fund will permit countries to finance their buffer stock contributions by the use of International Monetary Fund drawing rights. This permission was granted in recognition of the Agreement's importance as an intergovernmental stabilizing force in the commodity market. In total, out of contributions to the buffer stock of 20,000 tons equivalent to £27,000,000, the producing contributors can draw no less than £23,600,000 on the IMF facility.

The accompanying graph shows the price fluctuations from 1951 to 1972 in relation to price ranges considered desirable by Council at various periods. Prices from 1951 to 1969 are shown in pounds sterling per long ton as quoted on the London Metal Exchange. Beginning on January 2, 1970, prices were quoted on the London Metal Exchange in pounds sterling per metric ton.

Beginning July 7, 1972 prices are shown in pounds sterling and in Malaysian dollars per picul (1 picul equals 133 1/3 avoirdupois pounds). The Malaysian price is relevant since after the floating of the pound sterling, the International Tin Council decided that the market price of tin for the purpose of the operation of the buffer stock shall be expressed ad interim in terms of the ex-works price of tin on the Penang market in Malaysian dollars per picul.

Throughout 1964 and 1965 prices exceeded the established ranges and problems were mainly those of increasing the supply. The shortfall between production and demand was met in various ways, including decreases in consumer stocks, sales from governmental stockpiles and improved utilization of tin by consumers. The prolonged stimulus of price gradually had the desired effect of increasing mine production.

Production of tin in concentrates from 1960 to 1968 rose significantly and during 1968 exceeded consumption. To correct the imbalance, the Tin Council from September 1968 to the end of 1969 maintained an export control program. Tin prices rose from a level of £1,370 per ton at the beginning of 1969 to £1,620 per ton at the end of that year.

During 1970 production rose, the Tin Council's buffer stock, private stocks and United States Government stocks were on balance reduced, while consumption of tin declined in the major consuming countries. Tin prices thus declined as increased supplies became available, and at December 31 were £1,438 per ton, compared with £1,620 at the start of 1970. Though price movement was relatively large, prices were in the neutral 'no action' and upper 'may sell' zones for most of that year. Production and consumption of tin were nearly in balance.

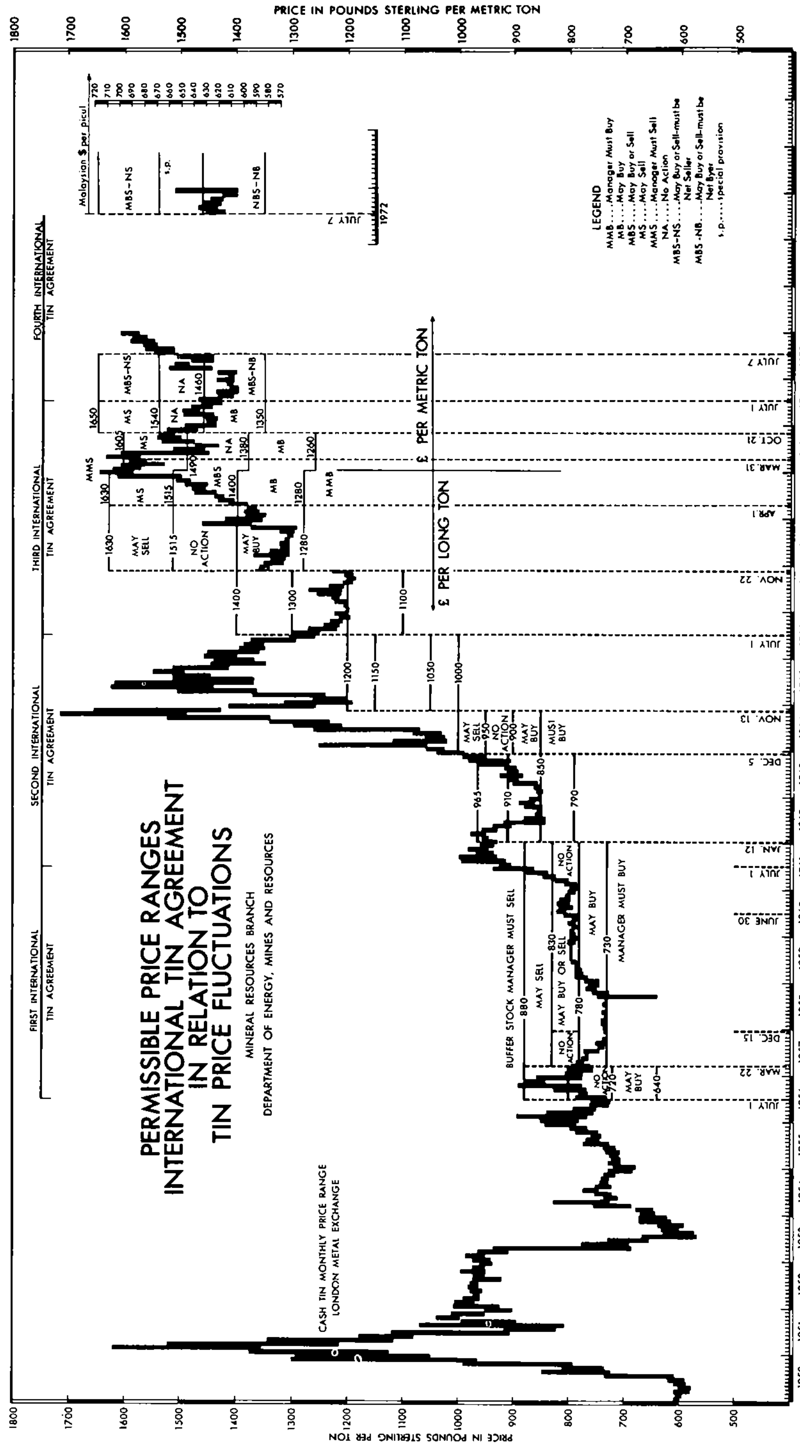
The Tin Council decided not to extend the authority of the Buffer Stock Manager to operate within the 'no action' middle sector after March 31, 1970; that is, the market mechanism after that date was allowed to operate freely in that sector. On October 21 the Council agreed to raise the floor price per metric ton in the Tin Agreement from £1,260 to £1,350 and the ceiling price from £1,605 to £1,650. The last previous adjustment, except for that made in November 1967 for the devaluation of the pound sterling and in January 1970 for the conversion from long to metric tons, had been made on July 1, 1966.

Under the Fourth Agreement effective July 1, 1971 the Buffer Stock Manager may buy or sell in the lower range but must be a net buyer for each financial

Table 4. Estimated world[1] production of primary tin metal, 1962, 1971-72

	1962	1971	1972
	(metric tons)		
Malaysia	83,390	87,095	91,001
Britain	19,050	23,153	21,333
Thailand	-	21,679	22,240
Indonesia	2,032	9,218	12,010
Nigeria	8,153	7,348	6,744
Bolivia	2,056	6,820	6,730
Australia	2,747	6,333	7,025
Spain	920	4,490	4,037
United States	5,588	4,450	4,000
Belgium	8,745	3,940	3,923
Brazil	1,700	3,424	3,583
South Africa	833	1,440	1,400
Republic of Zaïre	622	1,350	1,400
Total including countries not listed	145,904	186,300	190,400

Source: International Tin Council, Statistical Bulletin.
[1]Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.
– Nil.


PERMISSIBLE PRICE RANGES
INTERNATIONAL TIN AGREEMENT
IN RELATION TO
TIN PRICE FLUCTUATIONS
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
PRICE IN POUNDS STERLING PER METRIC TON
PRICE IN POUNDS STERLING PER TON
FIRST INTERNATIONAL TIN AGREEMENT
SECOND INTERNATIONAL TIN AGREEMENT
THIRD INTERNATIONAL TIN AGREEMENT
FOURTH INTERNATIONAL TIN AGREEMENT
CASH TIN MONTHLY PRICE RANGE
LONDON METAL EXCHANGE
BUFFER STOCK MANAGER MUST SELL
MAY SELL
MAY BUY OR SELL
NO ACTION
MAY BUY
MANAGER MUST BUY
£ PER LONG TON
£ PER METRIC TON
Malaysian $ per picul
LEGEND
MMB.....Manager Must Buy
MB.....May Buy
MBS.....May Buy or Sell
MS.....May Sell
MMS.....Manager Must Sell
NA.....No Action
MBS-NS.....May Buy or Sell-must be Net Seller
MBS-NB.....May Buy or Sell-must be Net Buyer
s.p.....special provision

quarter; similarly the Manager may buy or sell in the upper range but must be a net seller. The Council decided that the middle range (£1,460-1,540) will remain a 'no action' zone.

On July 7, 1972 the International Tin Council established the following new ranges: floor price M$583 per picul; middle sector M$633 to M$668 and the ceiling price at M$718 per picul.

In January 1973 the International Tin Council imposed a 72-day freeze on tin exports at 1972 levels; thus during the control period exports will be fixed at a maximum of 35,040 tons. The freeze went into effect on January 19 and will continue through March 31, 1973. The Buffer Stock Manager's operational price ranges remained unchanged, but the manager has been allowed to operate temporarily in the 'middle sector' provided he acts as a net seller in the upper half of this sector. The Council imposed this measure as a safeguard to prevent prices from skyrocketing because of export controls.

Price maintenance by buffer stock action resulted in the accumulation of 35 tons in 1966, rising to 4,755 tons by the end of 1967 and 11,290 tons at the end of 1968. The Council reduced its stocks during the period of export controls in 1969 to 4,590 tons at the end of the year and made further reductions in 1970 to 1,213 tons. Stocks held by the Buffer Manager were increased significantly during 1971, a year of slow economic growth and resultant weak demand for tin, to 6,637 tons as of December 31. Accumulation by the Buffer Stock Manager was particularly high in the fourth quarter, when the Manager apparently successfully exerted his influence to keep the price from falling below the £1,400 level. An oversupply situation still prevailed during early 1972 and buffer stocks rose to 8,099 tons in the first quarter. However, an optimistic forecast of rising consumption made during the Conference on Tin Consumption (London, March 13-17, 1972) resulted in a more buoyant market and accumulation of inventories during much of the second quarter, permitting the Buffer Stock Manager to hold stocks at the same level. These stood at 8,119 tons on June 30, 1972. However, at midyear in spite of this improvement in demand the increase in new production was very rapid, again outpacing demand, thus forcing the Buffer Stock Manager to support the market for the rest of the year. It was disclosed that buffer stocks were at 10,131 tons on October 5, 1972, and at 12,479 tons on December 31, 1972.

This deteriorating situation in the balance between supply and demand prompted the consideration of export controls first during the October 1972 meeting of the International Tin Council in Jakarta and then during the January 1973 meeting in London when controls were finally imposed as noted above. Hopes have been expressed that because of a very favourable forecast for continued growth in consumption during 1973, the export controls will only be of short duration.

At the Jakarta October meeting total resources of the buffer stock were increased to some £36.5 million by a decision of the Council to allow the Buffer Stock Manager to borrow an additional £8.0 million using the stock held as collateral.

Another important stockpile of tin in the world is that held by the United States in their stockpile of Strategic and Critical Materials. This stockpile originally held 348,310 long tons of tin in 1962, before disposals began. By July 1, 1968, when all commercial U.S. stockpile sales were suspended, these stocks were down to 257,524 long tons.

The stockpile objective was raised on March 27, 1969, from 200,000 to 232,000 long tons, leaving 25,524 long tons authorized and available for disposal. Releases totalled 2,046 long tons in 1969, 3,069 in 1970, 1,736 in 1971 and 361 long tons in 1972, all under the program of the United States Agency of International Development (AID). At the end of 1972 the U.S. stockpile held 18,312 long tons of uncommitted excess stock authorized for disposal.

More than 75 per cent of world tin mine output is

Table 5. Estimated world[1] tin position, 1970-72

	1970	1971	1972^e
		(metric tons)	
Ore supply			
Production of tin-in-concentrates	185,700	186,800	197,500
Stock at year's end	20,100	14,600	13,400
Primary metal supply smelter			
Production of tin metal	183,600	186,300	190,400
Net sales to centrally planned countries	4,593	4,913	. .
Government stockpile sales			
Buffer Stock: stocks at end of year	1,232	6,637	12,479
Commercial stocks at year's end (metal)	43,400	46,200	48,200
Primary metal consumption	184,800	187,000	190,800

Source: International Tin Council, Statistical Bulletin.
[1]Excludes countries with centrally planned economies except Czechoslovakia, Poland and Hungary.
^{e}Estimate; . . Not available.

derived from dredging and hydraulicking operations. Lode mines account for most of the output of Bolivia, Australia, Britain and South Africa. Concentrating processes for alluvial or lode tin are chiefly based on relatively simple gravity separation methods that produce concentrates ranging from 50 to 75 per cent tin. Typical concentrates as delivered, for example, to Indonesia's Mentok smelter in 1972 graded 65 to 72 per cent tin. Lode mining tin companies have recently installed flotation plants to complement gravity separation and improve the recovery of other metals as well as some very fine tin. Some companies that have installed flotation plants are South Africa's Union Tin Mines Ltd. (installation, 1971); Australia's Cleveland mine (1972) and Renison mine (1970); the Catavi mill in Bolivia (1970); in Britain, the new Wheal Jane mine of Consolidated Gold Fields Limited (1971); and South Africa's Rooiberg Minerals Development Company completed new flotation facilities in early 1973.

During the last four years, Australia has overtaken Zaïre and Nigeria to become the fifth largest tin producer in the western world. The real impetus for the upsurge in mine production has come from three principal hard rock deposits: Renison and Mount Cleveland in western Tasmania and Ardlethan in central New South Wales. These mines, which collectively already produce about 6,500 tons per year, have expansion plans which will further raise their total output to between 10,000 and 12,000 tons by 1975. Australia's other significant producers include Aberfoyle Ltd. (Tasmania) Dominion-Tullabong and Gibsonvale Alluvials N.L. (New South Wales) Greenbushes Tin N.L. (Western Australia) and three sizeable producers in Queensland: Metals Exploration N.L., Ravenshoe and Tableland. The last two are Australia's last surviving dredge operations. Prospects are also good for offshore exploration in the next few years, particularly in the Bass Strait between the mainland and Tasmania.

As part of a five-year expansion program, Associated Tin Smelters installed a new smelting furnace and ancillary equipment at their Alexandria tin smelter in 1972 at a cost of A$400,000. This increases the smelter's handling capacity to 15,000 tons of concentrates per year against 9,450 tons in 1971. Australia exports its surplus concentrates for smelting mainly to Britain and Malaysia.

Mine production in Britain in 1972 is forecast to increase to about 3,000 tons as compared to 1,816 tons in 1971 and 1,722 tons in 1970. At the beginning of 1973 the principal mine, Wheal Jane was producing at an annual rate of 1,800 tons against an initial target rate of 1,400 tons. Output will further increase after March 1973 when deepening and re-equipment of the principal shaft will be completed. Consideration is now being given to doubling the current output, which can be achieved with only minor additions to the existing treatment plant. The Pendarves mine of Camborne Mines Limited continues to have recovery and throughput problems at its mill commissioned in February 1972. British metal production in 1972 was about 22,000 tons, or slightly higher than in 1971.

The largest lode tin mines are Bolivian, from which concentrates were exported mainly to Britain, with smaller amounts to the United States, West Germany and the U.S.S.R. In addition the country's German-built Vinto smelter commissioned in January 1971 by Empressa National de Fundiciones (National Foundry Company) operated near its initial rated capacity of 7,500 tons per annum by the end of 1972. There is a provision for increasing its capacity through two further stages, each of 7,500 tons, but current conditions on the supply of suitable concentrates in Bolivia make the timing of this expansion very uncertain. Bolivia is still experiencing major problems in recovery and beneficiation. The country produces concentrates grading 20 to 60 per cent tin, with recoveries that range from less than 50 per cent to 72 per cent. Significant improvements will be made in the next few years with the installation of volatilization plants to treat low-grade tailings, upgrading this material to about 50 per cent tin which is suitable for smelting. Corporation Minera de Bolivia (Comibol), estimates that some 272,000 tons of tin lie in waste material in Bolivia's state-owned mines alone, more than the country's past 10 years of production. These tailings grade between 0.07 and 3.0 per cent fine tin. The U.S.S.R. under the terms of a $27.5 million credit line to Bolivia for equipment will supply $6 million for a volatilization plant at Potosí to be operational by June 1974, and subsequently for similar plants at Oruro and Quechisla. The U.S.S.R. is also providing $8.5 million for mining equipment. Poland and Czechoslovakia have also expressed an interest in supplying equipment and know-how in exchange for tin. A United States company, The International Metal Processing Company reached a 10-year agreement with the Bolivian Government, on a 45/55 joint venture basis, to work tailing dumps at the major Catavi and Potosí mines and to develop the Huari-Huari zinc-tin mine. The Israeli company, United Development, has signed a letter of intent to invest up to $100 million in developing mineral deposits in the Potosí region. The World Bank is assisting Bolivia with loans for infrastructure, notably for railway development.

Brazil has the potential of rapidly becoming a very important producer of tin, based on its large resource base, mainly in the western state of Rondonia. Potential reserves have been estimated at between 3 million and 5 million tons of tin. According to International Tin Council data, Brazilian production for 1970 was estimated at 4,296 tons, and for 1971 at 2,098 tons. The 1972 output is estimated at 2,850 tons. The drop in production from 1970 levels was due to rationalization of production on the basis of long-term planning. New laws prohibited 'wildcat' prospecting and mining and a system of large concessions conducive to modern production methods was introduced. More than fifty companies obtained new leases; several began intense exploration and six companies began mining in 1972. Output is expected to increase rapidly over the next few years. Some Brazilian sources already estimate current domestic output at much higher levels. Brazil has two tin smelters which operate partly on imported ores. The 1972 metal production is estimated at 4,200 tons.

Burma, currently producing 500 tons of tin a year compared with 6,000 tons annually prior to World War II, has begun a planned program of mineral exploration and extraction, with foreign aid. The U.S.S.R. has agreed to revive the Mawchi tin-tungsten lode mine, formerly a major producer. The country has a better potential, however, in developing some of its placer deposits. Canadian and West German aid in prospecting and equipment supplies has also been made available.

The Indonesia State Tin Enterprise, P.N. Timah, began construction on the expansion of the Peltim smelter. It was commissioned in 1967 with a designed capacity of 13,000 tons per year but achieved an operational capacity of only some 10,000 tons. Improvement to three existing rotary furnaces affording optimum capacity utilization will be achieved this year. In addition construction of stationary furnaces will increase capacity to 28,000 tons, with trial runs expected by 1974. This expansion will be greatly facilitated by the completion of the nearby Mentok Harbour to accommodate 19,000 ton dwt vessels in 1972. Almost all of the Indonesian output comes from dredging and hydraulic mining on and off Bangka Island (60%) Belitung Island (25%) and Singkeg Island (8%). Some 27 dredges were operational in early 1972.

Production in Laos has improved and is estimated to be about 2,000 tons in 1972. A further increase in 1973 is expected.

Malaysia, the first world tin producer had an estimated production of tin in concentrates of 77,000 tons, the highest output since the record 79,400 tons in 1941. In mid-1972 Malaysia recorded production from 1,043 mining units, including 62 dredges and 932 gravel pumps. The labour force in tin mining was 44,895. The Selangor Dredging Berhad Company is building the largest dredge in the world. It will have an annual capacity of 10,300,000 cubic yards per year and will be in operation by the end of 1973. Malaysian dredging operations are on inland properties but offshore dredging ventures are pending final resolution of protracted negotiations for mining rights offshore from Malaysia's west coast.

Nigerian output of tin, now all from alluvial deposits, is declining and the Makeri smelter at Jos is operating at less than half its designed capacity. This trend is expected to continue. A lode mine at Luruie could possibly be developed soon, partly compensating for the decline.

South Africa's output in 1972 was higher than that of 1971 principally because of continuing increases in production and recovery at the leading Rooiberg mine. This mine appears to be assured of many years of profitable operations. Reserves at the second largest Union Tin mine, however, are being depleted rapidly.

Thailand's mine production in 1972 was maintained at the same level as in 1971. Longer-term plans include increased offshore mining with round-the-clock operations throughout the monsoon season with new dredges, possibly by 1975. The Thaisarco smelter on Phuket Island lost some output between August 23 and September 16 when one furnace broke down. Metallurgical and operational improvements, however, led to a forecast metal production for 1972 of 22,000 tons or slightly higher than 21,679 tons in 1971.

Uses

Tin metal is unequalled as a protective, nontoxic hygienic coating on steel. The manufacture of tinplate represents the largest market for tin. Approximately 85 per cent of tinplate is used by the can-making industry. Available world data indicate that 58,700 tons of tin were used in the first ten months of 1972 for the production of 9.76 million tons of tinplate, compared with 76,900 tons used for a production of 12.3 million tons in all of 1971.

The tin coating on steel varies with the product mix of tinplate plants, from 0.25 pound per base box (5.6 g/m^2) for electrolytic tinplate up to 1.25 pounds (28 g/m^2) for the hot-dip process. Tinplate is sold by the base box (31,360 square inches). Between 1966 and 1971, 19 new electrolytic tinplate lines have been added for an increase in capacity of 2.7 million tons.

New EL lines, mostly dual purpose with the capability of producing both tinplate and steel with other coatings have been added in Britain, Canada, Germany, Japan and the United States during 1972. In early 1973 The Broken Hill Proprietary Company Limited commissioned a A$17.9 million, 259,000 tons tinning line at Port Kembla which will eliminate the need for tinplate imports during the seventies for Australia. France is also commissioning a new line at Dunkirk in 1973.

The technology of can making is changing with better and more economic uses being made of coiled tinplate. Other developments include the use of double-reduced tinplate and of jet soldering techniques for can side seams. A tin coat also imparts an inherent lubricity to tinplate, an important characteristic for the recently introduced deep-drawn and wall-ironed can-making process. Seamless cans could compete in the beer and beverage can market in which chrome-plated steel (TFS) or aluminum have already acquired a strong foothold, increasingly replacing glass containers. This is a large and expanding market; for instance in 1971 total can shipments in the United States were 159 million base boxes, of which 37 million were for beer and 28 million were for soft drink containers. Crown Cork & Seal Corporation in the United States was the first to achieve commercial production of one-piece D&I tinplate cans in 1971; in 1972 American Can Company brought into production a similar line at Edison. In Britain, The Metal Box Company is starting commercial production of D&I cans in 1973. There is currently no substitute for tinplate in most container applications involving food processing and the expansion of this market will continue, particularly in less developed countries. Despite yearly increases in absolute quantities of containers, the utilization of tin in tinplate has remained static in the past few years mainly because of more economical, thinner application of tin coatings. In the United States the tinplate industry, for example, utilized 11.34 pounds of tin per ton of tinplate in 1970, 11.16 pounds in 1971, and 10.85 pounds in 1972 (9 months). This can be compared with a utilization of 12.13 pounds per ton of tinplate for the world for the same period. While most processed food products are now packed in cans manufactured from electrolytic tinplate, demand for hot-dipped (H.D.) tinplate material for canning highly corrosive foods such as fish remains strong in some countries. In the developed countries, H.D. tinplate is being increasingly replaced by electrolytic, particularly by differential tinplate, which carries a heavier coating on one face than on the other.

After tinplate, solders are the second largest tonnage users of tin, estimated at 23 per cent in 1971, the last year available, with indications that it is fractionally lower for 1972. Uses for tin solder (60-63%) tin in the electronic industry, are growing rapidly; tin remains unchallenged as the means for interconnecting components, giving utmost reliability. Newer applications are the mass-production of 'tailor-made' preforms based on discs and washers punched from foil and the use of a tin-lead powder and flux mixture that fuses on heat application. Tin and tin-rich coatings are also widely used to ensure highest solderability.

Soft solders are used to join side seams of cans (2-3% Sn) and as lead-rich body-filling solders (2% Sn) in the automotive industry. Motor-car radiator cores are another important application. This market could run into some stiff competition with the announcement by some large European radiator manufacturers that they have solved the problems of mass-producing aluminum radiators. Use of solders in plumbing is important but is not increasing in proportion to gains in the construction industry because of the increased use of PVC (polyvinyl chloride) plastics.

The alloy applications of tin have a long tradition. Babbitt and white metal alloys are used for bearings and so are aluminum-tin alloys, which have a higher fatigue strength. Newer bearing materials include chromium- and beryllium-inoculated tin-base alloys offering markedly improved mechanical properties. Copper-tin alloys such as bronze and gunmetal (up to 12% Sn) have an average tin content of about 6 per cent and account for about 7 per cent of the world primary tin consumption or for about 12,000 tons of primary tin plus about 28,000 tons of secondary tin. The gunmetals contain copper, tin and zinc and sometimes lead to improved machineability. Continuous casting of standard shapes has reduced fabrication cost and caused renewed interest in bronze as an engineering material. A heat-treatable tin-bronze has now been developed, giving added strength.

Titanium-tin alloys bearing 2 to 11 per cent tin are used increasingly in the aerospace industry, especially in supersonic jets. For example the British-French Concorde utilizes these alloys. Terneplate, an alloy of 80-88 per cent lead and 20-12 per cent tin, has a three-century tradition as a most durable roofing material. It shows signs of revival in the United States. Other applications for terneplate are in automotive car and oil filters and some fixtures and in critical body parts, for example the undersides of electric golf carts. A possible future use with large tonnage potential would be as a replacement of copper in radiator cores.

Pewter is again becoming more popular. Pewter plate and beaker castings, for instance, commemorated the Munich 1972 Olympics. Modern methods of making pewterware from rolled sheet have recently been introduced. Pewter is pure tin hardened by the addition of copper and antimony; representative compositions range from 91% tin, 2% copper and 7% antimony to 92% tin, 5% copper and 3% antimony. Lately, the Association of British Pewter Craftsmen drew up plans for guaranteeing a minimum of 90 per cent tin in British pewter articles.

Fusible alloys of tin, bismuth, lead, cadmium and sometimes indium are used in safety devices such as heat fuses. Diecasting alloys of tin, antimony and copper have applications in jewelry.

As a minor alloying agent in other metals tin is widely used; for example alloy AP (antipollution) bronze is a corrosion-resistant copper-tin-aluminum alloy for condenser tubes in power stations operating in polluted waters. Tin accounts for 5.5 to 9.0 per cent of this alloy. Tin is a constituent in superconductive alloys such as intermetallic Nb_3Sn. Tin is also used in special protective coatings, particularly as a tin-nickel alloy electroplate which has excellent corrosion resistance, high hardness and the power of retaining an oil film.

A relatively new application is the use of small quantities of tin (approximately 0.1%) in cast iron for engine blocks. Adding tin assures a uniformly hard, wear-resistant and thermally stable perlitic structure in the castings. Current consumption for this usage is estimated at 1,000 tons a year. Tin has also an application in powder metallurgy primarily for sintered bronze bearings (sealed, self-lubricating). A new application is powder-sintered bronze-teflon bearings. Tin plus copper is replacing other metallic additions to iron powders to improve the quality of conventional sintered iron alloys but only a substantial reduction in the price of tin powder could lead to a large market expansion for such products. Some encouragement in this field is provided by recent experiments in West Germany on the use of water-atomized powder directly from tinplate scrap.

Pure tin is used in collapsible tubes especially for pharmaceutical products. It is used as a molten bath in the float-glass process for making perfectly flat glass sheet. Tin is also marketed as tin oxide for polishing applications; a newer use of tin oxide is in the manufacture of conducting glass and glass resistors.

Tin is used widely in organotin compounds and inorganic tin compounds. Chemicals, however, account for consumption of 5,000-10,000 tons, much of which comes from secondary tin. Growth potential from this modest base is excellent. The main uses of organotins are as: dioctyltin stabilizers for PVC; triphenyltin fungicides in agriculture; and tributyltin in industrial biocides and disinfectants. In inorganic compounds stannous chloride and stannous sulphate as well as sodium stannate and potassium stannate are used as electrolytes in the tin-plating process. The chloride also stabilizes the colour and perfume of soap. Stannic oxide is an opacifier in enamels. Stannic chloride is a basic chemical in the manufacture of the organotin compounds. Under development is the use of organotin chemicals as biocidal compounds to combat tropical diseases, for example schistosomiasis (blood flukes) by eliminating the main carrier, a water snail.

Tin chemicals are used as highly efficient catalysts in polyurethane foam technology and in the construction industry, and as catalysts in silicone elastomers, also known as semiplastic sealants, a rapidly expanding application. Organotins have outstanding stabilizing properties for the production of PVC compounds and roofing materials, as well as in the packaging industry.

The high-purity tin produced in Canada by Cominco, 59 grade (99.999%) and 69 grade (99.9999%) is used mostly in metallic form in the electronics industry. Some is used to produce semiconductors such as a tin-lead telluride for advanced solid-state radiation detection devices. Tin reclaimed by M & T Products of Canada Limited is in the form of potassium stannate and is used directly in electroplating.

Outlook

The short-term outlook for tin remains good, with indications that a genuine upturn in consumption somewhat prematurely heralded in 1972 will take place in 1973. Meanwhile, very substantial production gains in the last half of 1972 necessitated the recently imposed export controls. Under normal conditions a balance between supply and demand should be achieved by the middle of 1973, but it must be recognized that at least part of the stocks accumulated by the Buffer Stock Manager must be worked back into the market in the short term before export controls are lifted. Barring external factors such as releases from the U.S. stockpile, export controls should be lifted by or shortly after midyear and could be succeeded by a period characterized by 'adequate supplies – firm demand' patterns, that could spill over into 1974.

Beyond 1974, however, there is much less certitude that this balanced situation can be maintained, as such factors as important increases in output from current major producers, substantial improvements in milling and smelting recoveries, improvements in reclamation and secondary recovery, increased production from new fields or countries, potentially larger sales from China, relative decreases in imports by the U.S.S.R., all seems to converge to take effect in the same period of the midseventies (with the U.S. stockpile and its surplus still overhanging the market).

More specifically substantial 'percentage' production increases may be expected in the following countries: Australia, Bolivia, Brazil, Britain, Burma, Indonesia, Spain and the U.S.S.R. and possibly China. China may either de facto increase production or terminate its domestic stockpiling program that is currently deemed to occur at a rate of about 6,000 tons per year. Moderate increases can be further expected from Argentina, Laos, Malaysia, South Africa and Thailand and possibly new production from Algeria, Canada, France, Morocco, Yugoslavia and the United States (Alaska). On the other hand, decreases could still take place in Nigeria, Portugal, Zaïre and some other very small producers of central and east Africa.

Generally, if a potential serious threat of overproduction is to be averted, demand has to outperform the projected growth rates (currently foreseen to vary between 1 and 3 per cent per year), since on balance annual growth rate of production during the next five years could be between 4 and 5 per cent.

This appreciation of future marketing forces may in fact be subject to even greater apprehension if, as some observers believe, the United States begins stockpile releases. The United States finds it increasingly difficult to hold a large, marketable stockpile of tin (valued at over $1 billion) during a prolonged period of difficulties in its balance of payments, and rising domestic tin prices.

The pressures towards oversupply represent great potential problems for the producers, consumers and governments. Stabilizing measures by the International Tin Council, might have to include much more effective and almost permanent export controls and careful planning of new capacity in mining and smelting. Furthermore, phasing back metal from the U.S. stockpile into the marketplace, which will be inevitable, will have to be done in a measured way that would contribute to current efforts to maintain stability.

Tariffs

Canada

Item No.		Most Favoured Nation (%)	Item No.		Most Favoured Nation (%)
32900-1	Tin in ores and concentrates	free	38203-1	Sheet or strip, iron or steel, corrugated or not, coated with tin	12½
34300-1	Tin in blocks, pigs, bars, or granular form	free	33507-1	Tin oxides	15
34400-1	Tin strip waste and tin foil	free	34200-1	Phosphor tin	7½
33910-1	Collapsible tubes of tin or lead coated with tin	17½	43220-1	Manufactures of tin plate	17½

United States

Item No.		
601.48	Tin ore and black oxide of tin	free
622.02	Unwrought tin other than alloys of tin	free
622.04	Unwrought tin, alloys of tin	free
622.10	Tin waste and scrap	free

		After January 1 1970	1971	1972
608.91	Tinplate and tin-coated sheets	8.5% valued at not over 9.4¢/lb	8% valued at not over 10¢/lb	8% valued at not over 10¢/lb
608.92	Tinplate and tin-coated sheets	0.8¢ per lb valued over 9.4¢/lb	0.8¢ per lb valued over 10¢/lb	0.8¢ per lb valued over 10¢/lb
644.15	Tin foil	24%	21%	17.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

Titanium and Titanium Dioxide

D.D. BROWN

Manufactures of titanium dioxide pigments consume over 90 per cent of the growing annual output of the titanium mineral industry. Ilmenite ($FeOTiO_2$) is presently the mineral source of about 80 per cent of the noncommunist world's titanium requirements. Estimated world mine production of ilmenite in 1972 was 3.7 million short tons with over 80 per cent of supply being derived from Australia, United States, Canada and Norway. The remaining 20 per cent of titanium supply came from rutile (TiO_2) mining operations that produced about 360,000 short tons of rutile concentrates in 1972. Australia is the principal producer of rutile with over 95 per cent of world production. Demand for titanium dioxide (TiO_2) pigment was strong whereas titanium metal producers continued to face depressed markets.

Quebec Iron and Titanium Corporation (QIT) treated 2,016,500 long tons of ilmenite in 1972 in producing 821,800 long tons of titania slag (containing 70 to 72 per cent titanium dioxide) and 572,800 long tons of coproduct pig iron. Canada's titania slag output in 1972 was valued at $41,105,000 compared with $39,064,142 in 1971 when production was reported at 761,000 long tons. QIT is the only company in Canada mining and processing ilmenite for the production of titania slag used by manufacturers of sulphate-process TiO_2-based pigment for the paint, paper and plastics industries.

World resources of ilmenite are vast but adequate long-term supply of titanium will depend on the successful development of increased capacity to use ilmenite as a base for pigment manufacture in place of rutile since world supply of the latter may become critical in the 1980's. Indications are that world demand for high-grade TiO_2 feed for metal and pigment manufacture will increasingly outstrip supply of natural rutile. At projected rates of production, Australia's measured and indicated rutile reserves will be exhausted by 1990. They are the main source of world rutile supply. Therefore, TiO_2 resource materials for processing will increasingly have to rely on ilmenite, beneficiated ilmenite (synthetic rutile) and titania slag. An annual increase of 5 per cent a year in world consumption of ilmenite is considered realistic over the next several years and reserves are sufficient to supply this material at a reasonable cost well into the future.

Eventually, synthetic rutile from ilmenite will probably replace natural rutile as the prime base material for metal and pigment manufacture using the chloride process. Titanium slag and high-grade ilmenite concentrates will continue to be used for making titanium dioxide pigments by the sulphate process.

Canada. Quebec Iron and Titanium Corporation continued to increase its output of titania (TiO_2) slag in response to strengthened demand during the year.

Ilmenite is mined by open-pit methods in the Lac Tio–Lac Allard area of Quebec. The ilmenite deposit is one of the world's largest with reserves averaging 35 per cent TiO_2 and 40 per cent iron. The ilmenite is crushed to minus 3 inches, is transported 27 miles by rail to Havre-St-Pierre and is shipped up the St. Lawrence River to the company's beneficiation plant and smelter at Sorel near Montreal. The crushed ilmenite is upgraded from about 86 to about 93 per cent total oxides ot titanium and iron. The upgraded product is calcined in rotary kilns to lower the sulphur content, cooled, and mixed with powdered anthracite. Electric arc smelting of the calcine-coal mix yields titania slag and molten iron. Pigment-grade slag contains 70 to 72 per cent TiO_2.

Tioxide of Canada Limited, Sorel, Quebec, a subsidiary of British Titan Products Company Limited, operates a 33,000-ton-a-year sulphate process titanium-dioxide pigment plant. Much of the pigment production is sold in Canada but significant quantities are exported to the United Kingdom, Europe and the United States. The plant is based on QIT slag as its principal raw material.

Canadian Titanium Pigments Limited, a subsidiary of N L Industries, Inc., New York, produces titanium dioxide pigment at Varennes, Quebec. The company operates a 30,000-ton-a-year sulphate process plant based on QIT titania slag. The company closed its 10,000-ton-a-year capacity chloride-process TiO_2 pigment unit early in 1972. This unit and three other pigment plants in the United States were closed partly because of the high price of rutile and chlorine, the principal raw materials used, and other operating costs.

Canadian Tiron Chemical Corporation, announced plans to build a pilot plant to process 20,000 tons a year of upgraded ilmenite at Pointe-aux-Trembles, Quebec. The company expects to produce intermediate titanium dioxide products and an unfinished anatase-grade pigment when the plant begins operation in 1973. The ilmenite will be obtained from a deposit in the St-Urbain area.

Table 1. Canada, titanium production and trade, 1971-72

	1971		1972p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Titanium dioxide slag	..	39,064,142	..	41,105,000
Imports				
Titanium dioxide, pure				
United States	2,941	1,465,000	2,308	1,130,000
Belgium and Luxembourg	1,047	410,000	1,632	651,000
West Germany	575	258,000	915	450,000
United Kingdom	1,042	462,000	879	372,000
Japan	28	10,000	159	55,000
Other countries	308	111,000	–	–
Total	5,941	2,716,000	5,893	2,658,000
Titanium dioxide, extended				
United States	5,725	1,054,000	1,192	224,000
Titanium metal				
United States	123	1,144,000	209	1,788,000
United Kingdom	4	141,000	4	55,000
Japan	49	267,000	9	49,000
Netherlands	1	2,000	...	3,000
Total	177	1,554,000	222	1,895,000
Exports[1] to the United States				
Titanium metal, unwrought, incl. waste and scrap	117	127,781	12	8,746
Titanium metal, wrought	100	517,055	82	439,107
Titanium dioxide	8,057	3,166,245	17,385	7,353,452

Source: Statistics Canada, except where noted.
[1]U.S. Department of Commerce Imports for Consumption, Report F.T135; no identifiable classes are available from Canadian export statistics.
pPreliminary; – Nil; .. Not available; ... Less than 1 ton.

United States. The United States is the largest producer and consumer of ilmenite; it is also the largest consumer of rutile with annual imports accounting for over 50 per cent of Australia's exports of rutile. Forty-two U.S. companies reported consumption of about 200,000 tons of rutile. Eight companies used 84 per cent for the manufacture of TiO_2-based pigments by the chloride process, welding rod coatings accounted for 7 per cent of total consumption and the titanium metal industry accounted for most of the balance. Rutile was produced at one Florida mining operation in 1972. An estimated 700,000 short tons of ilmenite was produced in 1972 from six mining operations in the United States. The operations were based on placer deposits in Florida, Georgia, and New Jersey and a lode deposit in the Sanford Lake area of New York.

United States titanium metal demand continued weak with some improvement in the second half of the year. Slow demand in aircraft production along with reduced aerospace and military markets, which account for 84 per cent of metal sales, resulted in about 50 per cent excess ingot production capacity and larger producer stocks. United States consumption of titanium sponge metal increased to 13,068 short tons compared with 12,145 short tons in 1971. United States production of titanium ingot increased to 20,267 tons from 18,357 short tons in 1971. In an effort to support its distressed titanium metal industry, the United States government General Service Administration announced in March that it would purchase 6.5 million pounds of titanium sponge from each of two domestic producers over two years at $1.245 a pound.

Table 6. Production of ilmenite concentrates by countries, 1970-72

	1970	1971	1972
	(thousands of short tons)		
Australia	981	898	781
Canada[1]	845	855	920
Norway	638	707	720^e
United States	868	683	700^e
Malaysia	212	172	
Finland	167	154	
India	87	100	
Sri Lanka	93	94	600^e
Spain	30	26	
Brazil	23	22	
Japan	12	9	
Portugal	0.3	1	
Total	3,956	3,721	3,721

Source: U.S. Mines, *Minerals Yearbook* Preprint 1971; Commodity Data Summaries, January 1973.
[1]Titania slag containing 72% TiO_2.
^{e}Estimated.

Table 7. Production of rutile concentrates by noncommunist countries, 1970-72

	1970	1971	1972
	(short tons)		
Australia	405,156	404,244^r	349,932
Sierre Leone	48,593	5,704	
India	2,800	3,200	$10,000^e$
Sri Lanka	3,100	3,100	
Brazil	258	250	
Total	459,907	416,498	359,932

Source: U.S. Bureau of Mines *Minerals Yearbook* 1971 Preprint; Commodity Data Summaries, January 1973.
^{e}Estimated; ^{r}Revised; – Nil.

Table 8. Canada, consumption of titanium dioxide pigments

	1968	1969	1970
Refined titanium dioxide			
Paint and varnish	27,413	27,841	27,281
Paper	4,776	4,986	4,894
Linoleum	843	1,564^r	1,786
Rubber	2,124	2,123	1,910
Miscellaneous non-metallic products	811	866	739
Plastic and synthetic resins	120	226	498
Toilet preparations	35	44	37
Industrial chemicals	57	79	71
Other chemicals	818	877^r	538
Extended titanium dioxide pigments, paint and varnish	8,473	8,812	6,654

Source: Statistics Canada.
^{r}Revised.

hiding power and chalking quality because of their differences in index of refraction and crystal structure. An extended titanium pigment containing 30 to 50 per cent TiO_2 is produced in smaller quantities. Because of the high refractive indices to TiO_2 pigments and consequent high degree of opacity, over one half of the industry's output is consumed in paints, varnishes and lacquers. In Canada, consumption of refined and extended titanium dioxide in their uses represents about 87 per cent of total consumption. Their use in paper, rubber, linoleum, plastics and coated fabrics constitutes most of the remaining consumption.

Titanium metal is a low-density, high-strength, corrosion-resistant, silver-grey metal. In the United States, because of its high strength-to-weight ratio, about 84 per cent of consumption is utilized in the aerospace industry. Because of its excellent resistance to corrosive solutions it is increasingly consumed in the chemical and electrochemical processing industries and in marine applications. The principal disadvantages to more widespread use of titanium are its high cost, processing difficulties, and reactivity at high temperature.

Titanium minerals

Ilmenite ($FeOTiO_2$), theoretically, is composed of 52.66 per cent TiO_2 and 47.34 per cent iron oxide (FeO). It is widely dispersed in nature with the important lode deposits being found as segregated masses in gabbro or anorthosite. Ilmenite is usually found in a complex intergrowth with iron oxide minerals, particularly magnetite. Economic ilmenite deposits are also found in heavy mineral alluvial and beach sands. Rutile (TiO_2) is typically composed of 89.5 to 99 per cent TiO_2 because iron and other impurities may constitute up to 10 per cent of the mineral. Economic rutile deposits are found in beach and alluvial sands usually in association with ilmenite and other heavy minerals. Titanium minerals such as anatase, brookite and leucoxene are associated with ilmenite and rutile and often comprise part of the marketed mineral concentrates.

Commercial ilmenite concentrates typically contain between 44 and 60 per cent TiO_2, rutile concentrates average about 95 per cent TiO_2.

Table 9. United States, titanium metal data, 1967-71

	1967	1968	1969	1970	1971
			(short tons)		
Sponge metal					
Imports for consumption	7,144	3,443	6,332	6,543	3,023
Industry stocks	2,900	2,600	1,909	2,516[r]	2,724
Government stocks (DPA inventories)	20,711	20,711	20,385	19,994	19,994
Consumption	20,062	14,237	20,124	16,414	12,145
Scrap metal consumption	5,822	4,701	7,566	7,242	6,149
Ingot[1]					
Production	25,920	19,234	28,490	24,331	18,357[r]
Consumption	25,386	18,323	27,082	23,687	17,058
Net shipments of mill products[2]	13,634	11,900	15,940	14,480[r]	11,241

Source: U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1971.
[1]Includes alloy constituents. [2]Bureau of the Census and Business and Defence Services Administration, current industrial Reports Series BDCF-263.
[r]Revised.

Prices

Prices in the United States published in Metals Week of December 25, 1972

	(U.S. $)
Titanium ore fob cars Atlantic ports, Great Lake ports	
Rutile, 96% per short ton delivered within 12 months	175
Ilmenite, 54% per long ton, shiploads	22-24
Slag, 70% per long ton, fob shipping point	50
Titanium metal, sponge, per lb fob mine or mill max, 115 Brinell, 99.3%, 500 lb	1.32
Mill products per lb delivered, 4,000-lb lots	
Billet, Ti-6AL-4V (8″ diam. random lengths)	2.76
Bar, Ti-6AL-4V (2″ diam.)	3.80
Ferrotitanium, delivered	
Low carbon, per lb, Ti, 25-40% Ti	1.35
Medium carbon, net ton, 17-21% Ti	375*
High carbon, net ton, 15-19%	310*
Titanium dioxide, Canadian prices, quoted in *Canadian Chemical Processing,* of titanium pigments, effective October 1972	
Anatase, dry milled, bags, car lots, delivered, East, per 100 pounds	22.50
Anatase, regular, bags, car lots, delivered, East, per 100 pounds	25
Rutile pigment, bags, car lots, delivered, East, per 100 pounds	27

QIT, in January 1972, according to *Metals Week*, increased its price of Sorel slag by $2 to U.S.$50 a long ton, fob, Sorel, Quebec; there had been a price increase of $3 a ton to $48 a ton the previous year.

*1971 prices.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900-1	Titanium ore	free	free	free
92825-1	Titanium oxides	free	12½	25
34715-1	Sponge and sponge briquettes, ingots, blooms, slabs, billets and castings in the rough, of titanium alloys for use in Canadian manufactures (expires 31 October 1974)	free	free	25
37506-1	Ferrotitanium	free	5	5
34735-1	Tubing of titanium or titanium alloys for use in Canadian manufactures (expires 28 February 1974)	free	free	25
93207-6	Titanium whites, not including pure titanium dioxide	free	12 ½	25

United States

Item No.		On and After January 1 1971	1972
		(%)	(%)
601.51	Titanium ore, including ilmenite, ilmenite sand, rutile and rutile sand	free	free
629.15	Titanium metal, unwrought, waste and scrap (duty on waste and scrap suspended on or before June 30, 1973)	18	18
629.20	Titanium metal, wrought	18	18
607.60	Ferrotitanium and ferrosilicon titanium	6	5
473.70	Titanium dioxide	9	7.5
422.30	Titanium compounds	9	7.5

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Tungsten

D.D. BROWN

Demand for tungsten (W) is closely linked to levels of activity in the alloy steel and machine tool industries which are its largest markets. The steel industry uses tungsten as a hardening agent in high-strength and high-speed tool steels; the machine tool industry also makes extensive use of tungsten carbide cutting tools, dies and wear-resistant parts. Demand was indicated by the United States domestic consumption of tungsten in concentrate, which dropped in 1971 to an estimated 11.6 million pounds from the peak level of 16.7 million pounds reached the previous year, a decline of 31 per cent. In 1972, estimated U.S. consumption of concentrates increased 14 per cent to 13.2 million pounds of contained tungsten. The gradual recovery of industrial activity in 1972 and prospects of record world steel production in 1973 were not reflected in the European tungsten market. European prices dropped about 28 per cent from the previous year and tungsten market activity was sluggish throughout the year. The outlook for 1973 is for continued improvement in demand and prices.

Following the impact of the reduced world industrial activity in 1971 and the first half of 1972, worldwide recovery of tungsten demand and somewhat higher prices can be expected in 1973. Through the remainder of the 1970's world demand for tungsten is expected to increase about 5 per cent annually. United States government stockpile tungsten prices will likely remain stabilized for some time; however, world prices are expected to increase toward the GSA base price of $55 an stu* as cumulative demand exerts pressure on available world supply. China possesses 75-80 per cent of total world tungsten resources and during the early 1960's it supplied about 40 per cent of world exports. Over the past several years, China's exports have declined; in 1970 it had reduced exports to about 5 million pounds or 10 per cent of world exports and in 1972 sales were estimated at 7 million pounds. Development of a critical supply shortage in the long term could presumably bring consumer dependence again on U.S. government stockpile sales and/or encourage increased supplies from China through price increases to or above the GSA base price. The uncertainty of Chinese trade makes any long-term evaluation of supply indeterminate. Barring re-entry of China as a major supplier, the ability of the noncommunist world to meet projected demand would eventually depend on increased prices to encourage exploration and development of tungsten resources.

World production of tungsten in ores and concentrates was estimated at 73.9 million pounds in 1972 including an estimated 35.3 million pounds from China, U.S.S.R. and North Korea.

Canada

Production. Canada's production (shipments) was 4,956,000 pounds of tungsten trioxide (WO_3) in scheelite ($CaWO_4$) concentrates in 1972, compared with 4,624,208 pounds of WO_3 in 1971. Mine production came from two producers – Canada Tungsten Mining Corporation Limited's mine and a 600-ton-a-day mill and concentrator at Tungsten in the Northwest Territories, near the Yukon border, about 135 miles north of Watson Lake, and Canex Placer Limited's mine and 500-ton-a-day mill and concentrator near Salmo, east of Trail in southeastern British Columbia.

Canada Tungsten Mining Corporation Limited produced 2,517,395 pounds of contained tungsten or 158,706 short ton units of WO_3 in scheelite concentrates in 1972. Canada Tungsten estimated its ore reserves at December 31, 1972, at 240,000 short tons of ore in place at its operating open-pit mine with an average grade of 1.65 per cent WO_3. No ore was mined in 1972 from an additional reserve of 3,500,000 tons of lower-grade chert material estimated to contain 0.65 per cent WO_3 a ton outlined in the 1971 drilling program. The stockpile of crushed ore at mine site at year-end contained 157,600 tons calculated to grade 1.06 per cent WO_3. Canada Tungsten, 39.5 per cent owned by American Metal Climax, Inc., is one of the largest tungsten producers in the noncommunist world.

The Tungsten Division of Canex Placer Limited, a wholly owned subsidiary of Placer Development Limited, treated 198,000 tons of ore averaging 0.58 per cent WO_3 of which approximately one fifth was recovered as a high-grade table concentrate. The concentrator recovery was 81.5 per cent. Sales were reduced in anticipation of a stronger market and inventory at year-end was 53,275 stu, an increase of 30,355 stu during the year. The company estimated reserves of broken and unbroken ore at December 31, 1972, at 104,000 short tons grading 0.55 per cent

*A short ton unit (stu) is 20 pounds of WO_3 and contains 15.862 pounds of tungsten (W).

Table 1. Canada, tungsten production, imports and consumption, 1971-72

	1971		1972[p]	
	(pounds)	($)	(pounds)	($)
Production[1] (WO_3)	4,624,208	..	4,956,000	..
Imports				
Tungsten in ores and concentrates				
Australia	–	–	221,500	440,000
People's Republic of China	–	–	18,400	38,000
United States	81,500	256,000	–	–
Mexico	41,800	117,000	–	–
Uganda	30,000	113,000	–	–
Total	153,300	486,000	239,900	478,000
Ferrotungsten[2]				
Britain	148,000	338,000	244,000	370,000
United States	50,000	176,000	8,000	15,000
West Germany	–	–	2,000	7,000
France	24,000	77,000	–	–
Total	222,000	591,000	254,000	392,000
Consumption (W content)				
Tungsten metal and metal powder	276,875	..	..	..
Tungsten wire	21,885	..	..	..
Other[3]	341,005	..	..	..
Total	639,765	..	..	..

Source: Statistics Canada.
[1] Producers' shipments. [2] Gross weight. [3] Includes tungsten ore, tungsten carbide.
[p] Preliminary; .. Not available; – Nil.

Table 2. Canada, tungsten production, trade and consumption, 1963-72

	Production,[1] WO_3 Content	Imports: Tungsten Ore[2]	Imports: Ferrotungsten[3]	Consumption, W Content
	(pounds)			
1963	1,224,305	645,500	624,100	903,924
1964	1,068,420	389,800	172,000	740,410
1965	3,824,660	357,400	354,000	877,614
1966	4,263,927	523,600	192,000	941,207
1967	267,600	233,600	192,000	891,411
1968	3,584,920	131,700	118,000	1,181,541
1969	4,063,488	426,500	210,000	1,050,824
1970	3,726,800	182,200	200,000	984,777
1971	4,624,208	153,300	222,000	639,765
1972[p]	4,956,000	239,900	254,000	..

Source: Statistics Canada.
[1] Producers' shipments of scheelite (WO_3 content). [2] Prior to 1964 reported in gross weight, commencing in 1964 in W content. [3] Gross weight. [p] Preliminary;
.. Not available

WO_3. Canex commenced production of tungsten concentrates in October 1970 from its Emerald and Dodger ore zones that were mined during an earlier operation that closed in 1958. The company reported that it would cease operations when the remaining reserves of tungsten ore are depleted by August 1973. Arrangements are being made to assist employees to relocate; disposal of assets and reclamation of the site will be carried out following closure of the mine.

Developments. Canada Tungsten Mining Corporation Limited carried out deep surface diamond drilling during the summer of 1972 to extend the new "E" zone discovered late in 1971 at its Flat River Property near Tungsten, Northwest Territories. The "E" zone lies about 1,800 feet north and at a lower elevation than the main open pit. Work on a 4,000-foot adit that commenced in October had advanced 437 feet by year-end. The adit will provide drilling stations for underground exploration. When the results of the underground development program are known, consideration will be given to changing to underground mining as an alternative to mining the lower-grade chert from an open pit.

Amax Exploration, Inc., a wholly owned subsid-

Table 3. Canada Tungsten Mining Corporation Limited production data, 1970-72

	1970	1971	1972
Pounds of tungsten produced	2,955,725	2,608,030	2,517,395
Short tons milled	176,813	181,596	178,828
Grade of ore (WO_3 content)	1.39%	1.19%	1.15%
Recovery of WO_3	78.63%	76.39%	79.83%

Source: Company reports.

iary of American Metal Climax, Inc., New York, reported in February 1973 that it has identified a scheelite deposit on the Yukon-Northwest Territories boundary, in the MacMillan pass area, some 240 miles northeast of Whitehorse, Yukon, and about 5 miles from the Canol Road. The prospect was first staked in 1962 and since that time the company has outlined by exploration and drilling a deposit with erratic mineralization and wide variations in grade. Over 30 million tons with an average grade of 0.9 per cent tungstic oxide (WO_3) have been indicated. Additional drilling and bulk sampling are necessary before the mineralization is fully outlined and tonnage and grade estimates can be more accurately assessed.

United States

United States consumption of tungsten in products increased 13 per cent to 12.7 million pounds of tungsten compared with 11.1 million pounds during 1972. Tungsten was used in the form of tungsten carbide powder for cemented carbides, 40.3 per cent; metal powder, 39.7 per cent; ferrotungsten, 9.6 per cent; other tungsten materials, 10.4 per cent.

The United States reversed its position in 1972 from that of a net exporter to that of a net importer, a position it held prior to 1969. Imports for consumption burgeoned from 418,000 pounds in 1971 to an estimated 5.1 million pounds in 1972, the highest since 1959. In 1972, Canada supplied about 30 per cent of U.S. tungsten imports. Domestic U.S. mine shipments of tungsten ore and concentrates were 8 million pounds (W content).

The only sales in 1972 from United States tungsten stockpile surplus material were 3,457 pounds of subspecification-grade tungsten sold in April. No bids were received for tungsten concentrates during the rest of the year since London market prices have been below the United States General Services Administration (GSA) base price of $55 a short ton unit since mid-1971. The GSA base price in such a market tends to provide a price ceiling at $55 less the U.S. tariff of $3.97 an stu. It should be noted that in 1969 when the price of tungsten was above the GSA shelf price of $43 an stu sales from the stockpile were 38.2 million pounds. At December 31, 1972, there were approxi-

Table 4. Placer Development Limited, Canex Placer Production Data, 1971-72

	1971	1972
Pounds of tungsten produced	1,364,291	1,484,598[e]
Short tons milled	172,512	198,000
Grade of ore (WO_3 content)	0.61%	0.58%
Recovery of WO_3	..	81.5%

Source: Company reports.
[e]Estimated; .. Not available.

Table 5. Tungsten production in ores and concentrates, by countries, 1970-72

	1970	1971	1972[e]
	(thousands of pounds of contained tungsten)		
China[e]	17,600	17,600	15,700
U.S.S.R.[e]	14,770	14,800	14,800
United States	9,625[r]	6,900	7,900
North Korea[e]	4,794	4,800	4,800
South Korea	4,200	4,539	4,600
Bolivia	4,329	4,587	4,100
Portugal	3,105	2,911	3,500
Canada[1]	3,855	5,009	4,001
Australia	3,518	4,300	4,500
Brazil	2,364	3,081	
Peru	1,821	1,697	
Thailand	1,018	3,568	
Japan	1,466	1,556	10,000
Mexico	503	714	
Spain	1,069	1,148	
Burma	418	440	
Other countries	137	180	
Total	74,592	77,830	73,901

Sources: *Quarterly Bulletin* of UNCTAD (United Nations Conference on Trade and Development), Oct. 1972; U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1971; Commodity Data Summary, January 1973.
[1] From company reports.
[e] Estimated; [r] Revised.

Table 6. Consumption of tungsten, by end use, in the United States, 1971

	(thousands of pounds of contained tungsten)	(%)
Steel		
Stainless and heat resisting	187	1.7
Alloy	149	1.3
Tool	1,420	12.7
Superalloys	209	1.9
Alloys (excluding alloy steel and superalloy)		
Cutting and wear-resistant material	5,082	45.5
Other alloys	803	7.3
Mill products made from metal powder	2,044	18.3
Chemical and ceramic uses	381	3.4
Miscellaneous and unspecified	885	7.9
Total	11,160	100.0

Source: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1971.

Table 7. Consumption of tungsten in Canada by use, 1970-71

	1970	1971
	(lb of contained tungsten)	
Carbides	650,041	. .
Alloy steels	285,937	. .
Electrical and electronic	22,130	. .
Other[1]	26,669	. .
Total	984,777	639,765

Source: Compiled in Mineral Resources Branch from data supplied by Statistics Canada.
[1] Includes nonferrous alloys, chemicals and pigments.
. . Not available.

mately 68.7 million pounds of contained tungsten in United States government stockpile in excess of the stockpile objective of approximately 59.3 million pounds.

The GSA announced in June that it would continue to offer stockpiled tungsten to June 30, 1973, under its established two-part disposal program. Under this program, outlined on December 11, 1970, the GSA offers a maximum of 7 million pounds of tungsten for domestic consumption at a shelf price of $55 an stu and 6 million pounds for export at prices not less than the $55 shelf price. Since no bids were received for stockpile-grade tungsten in 1972 the GSA extended the program into 1973.

Japan

In Japan, total consumption was 6.4 million pounds of tungsten in 1972; 36 per cent was used in iron and steel production, 59 per cent in metal and carbides and 5 per cent in chemicals and others. Japanese tungsten imports in 1972 totalled 4.9 million pounds, up 21 per cent over 1971.

Uses

Cemented and fused tungsten carbides account for over half of total tungsten consumption in Canada and the United States. Tungsten is a basic material for a large variety of cemented (or sintered) carbide (generally WC) cutting tools, dies, bits and wear-resistant parts. Metal mill products made from tungsten powder consist of fused tungsten carbide (generally W_2C), which is cast into shapes for use as such or for subsequent crushing and use as hard-facing material.

Ferrotungsten, containing from 70 to 80 per cent tungsten, is used as an additive in the manufacture of tool steels. Alloy tool steel classifications range from low-alloy steels containing little or no tungsten to high-speed tool steels which contain from 1.5 to 18 per cent tungsten and other carbide forming elements. In high-temperature nonferrous superalloys, tungsten is important because it has the highest melting point of all metals, 6,170°F. It is used as a base-alloy with varying amounts of cobalt, chromium, molybdenum, nickel and other refractory metals to produce a series of hard, heat- and corrosion-resistant alloys for use in aerospace and high-temperature industrial applications. Stellite, a nonferrous alloy, containing from 5 to 20 per cent tungsten with cobalt, is employed in welding rods for hard-facing and high-speed tools. Pure or substantially pure tungsten metal is used in the manufacture of electrical contact points and in filament in all incandescent electric lamps. The chemical, sodium tungstate is used in pigments, in chemical analyses, in textile fireproofing material and in hard-surface materials.

Prices

The average 1972 London price of tungsten in concentrates dropped about 28 per cent from the previous year's average price of 22.46 pounds sterling a metric ton unit* (£/mtu) or about $49.52 a short ton unit ($/stu). Prices ranged from £16.75 an mtu ($39.34/stu) in January to a low of £14.00/mtu ($29.45/stu) in November. At year-end, prices were about £16/mtu ($33.68/stu).

* A metric ton unit (mtu) is equivalent to 22.046 lb of WO_3 and contains 17.48 lb of tungsten.

Tungsten prices according to Metals Week for December 1971 and 1972

	1971	1972
	(U.S. $)	(U.S. $)
Tungsten ore, 65% minimum WO_3 per stu of WO_3, duty included, GSA for U.S. market only		
Wolfram	55	55
Scheelite, $5.55 duty per stu of WO_3 effective Jan. 1, 1970, and to $4.76 per stu, effective Jan. 1, 1971	55	55
Ferrotungsten, per pound W, fob shipping point		
Low-molybdenum	4.60	4.60
High-molybdenum	. .	. .
"UCAR" high-purity	. .	. .
Dealer (export)	(n)4.50	4.50
Tungsten metal, per pound, cif U.S. ports		
Carbon red, 98.8%, 1000-pound lots	4.50	4.50
Hydrogen red, depending on Fisher No. range	5.43-6.94	5.43-6.94
Typical Fisher No. 400	. .	. .

(n) Nominal; . . Not available.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900-1	Tungsten ores and concentrates	free	free	free
34700-1	Tungsten metal in lumps, powder, ingots, blocks or bars and scrap of tungsten alloy metal	free	free	free
34710-1	Tungsten rod and tungsten wire	free	free	25
35120-1	Tungsten alloys in powder, pellets, scrap, ingots, sheets, strip plates, bars, rods, tubing, wire (expires October 31, 1971)	free	free	25
37506-1	Ferrotungsten	free	5	5
37520-1	Tungsten oxide in powder, lumps, briquettes	free	free	5
82900-1	Tungsten carbide in metal tubes	free	free	free

United States

Item No.		On and After January 1 1971	1972
601.54	Tungsten ore, on pounds W content	30¢	25¢
629.28	Tungsten metal unwrought other than alloys, lumps, grains, powders on pounds of W content	25¢ + 15% ad val	21% + 12.5% ad val
629.29	Ingots and shot	12.5%	10.5%
629.30	Other tungsten unwrought metal	15%	12.5%
629.25	Tungsten metal waste and scrap		
	Not over 50% tungsten on pounds of W content	25¢ + 7.5%	21¢ + 6%
629.26	Over 50% tungsten	12.5%	10.5%

		On and After January 1	
		1971	1972
629.35	Tungsten metal, wrought	15%	12.5%
	Tungsten unwrought alloys		
629.32	Not over 50% tungsten on pounds of W content	25¢ + 7.5%	21¢ + 6%
629.33	Over 50% tungsten	15%	12.5%
422.40	Tungsten carbide on pounds of W content	25¢ + 15%	21¢ + 12.5%
422.42	Other tungsten compounds on pounds of W content	25¢ + 12%	21¢ + 10%
607.65	Ferrotungsten on pounds of W content	25¢ + 7.5%	21¢ + 6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Uranium and Thorium

R.M. WILLIAMS

URANIUM

The uranium industry marked time during 1972, although some developments occurred in the marketplace which will tend to ease the growing oversupply situation during the next few years. Uranium prices appeared to bottom and several new sales contracts were announced, most notably between prospective Australian producers and Japan. Late in the year, a major Canadian sale with Spain was confirmed involving almost 9 million pounds of uranium oxide.

With little immediate relief to be seen in the uranium surplus situation, uranium exploration continued in the doldrums, except in Australia. Moreover, with the spectre of a world shortage of uranium enrichment capacity in the early 1980's, the need for reversing the downward trend in uranium exploration seemed to be of second or even third-order importance in both consumers' and producers' eyes. Producers' efforts were, consequently, directed toward the marketplace while consumers continued to seek solutions to the more pressing problems relative to building and licensing their nuclear power plants.

Longer-term forecasts were substantiated in 1972, however, with a resurgence of nuclear plant orders in both the United States and Europe. Canada's own nuclear power industry took another step forward with the order, finalized in October, of a 600 MWe (electrical megawatt) plant by The Quebec Hydro-Electric Commission (Hydro-Quebec). In addition, the third unit of The Hydro-Electric Power Commission of Ontario's (Ontario Hydro) Pickering Generating Station reached full power in May, giving the station a net output exceeding 1,500 MWe and making it the largest nuclear power station operating in the world* at that time.

Production

Canadian uranium production rose some 5 per cent in 1972 to 5,204 tons of uranium oxide (U_3O_8)** of which 4,898 tons U_3O_8 were shipped. The bulk of this output came from the Elliot Lake area of Ontario where Denison Mines Limited and Rio Algom Mines Limited produce from quartz-pebble conglomerates. Canada's third producer, Eldorado Nuclear Limited, produces from pitchblende, vein-type deposits near Uranium City, Saskatchewan.

In the Elliot Lake area, Denison operated its mill at an average of 4,300 tons * of ore per day treating a total of 1,454,000 tons of ore with an average grade of 2.87 pounds U_3O_8 per ton; 3,914,220 pounds of U_3O_8 were produced, which included recovery from the underground leaching program in mined-out areas. Some further improvement in productivity was achieved as a result of continued mechanization of the mining operation. Production was again concentrated in the northeastern section of the mine. Development work was directed primarily toward preparing a new mining area to the east, for which a 25-foot-diameter fresh-air intake will be raised a vertical distance of 1,760 feet beginning in early 1973 to an island in Quirke Lake.

Late in 1972, Denison announced that plans had been completed for the first phase of its mill expansion to a capacity of 7,100 tons per day. Detailed design was under way and construction was scheduled to begin in late 1973 for completion by 1975. Also of significance to Denison's future operations was an offer made by the company at midyear to amalgamate with Stanrock Uranium Mines Limited. Stanrock's property and producing facilities adjoin Denison's to the east; Stanrock discontinued operations in early 1970 because of lack of markets. The agreement had not been consummated at year-end**.

Rio Algom operated its Quirke mill at an average of 4,630 tons of ore per day, slightly in excess of its 4,500 ton-per-day capacity; a total of 1,551,000 tons of ore was treated with an average grade of 3.3 pounds of U_3O_8 per ton and an average mill recovery of 95.4 per cent to produce 5,158,000 pounds of U_3O_8. Some 4,471,000 pounds of this total were delivered under contracts. The New Quirke mine is now supplying the mill's total feed, mining at a rate (5 days/week) of 6,500 tons per day, well in excess of its orginally designed capacity. Considerable success was achieved in the development of a system of bench-stoping in the thicker ore of the mine and tests continued to determine the applicability of hydraulic backfilling for

* World excludes U.S.S.R., eastern Europe and China.
** 1 short ton U_3O_8 = 770 kilograms of uranium metal.

* Although nominal capacity is 6,000 tpd, present leaching capacity is limited to about 4,400 tpd.
**The amalgamation took effect on February 12, 1973.

Table 1. Uranium production in Canada, by province, 1971-72

	1971		1972^p	
	(pounds)	($)	(pounds)	($)
U_3O_8 shipments				
Ontario	7,009,985	..	8,469,000	..
Saskatchewan	1,204,406	..	1,327,000	..
Total	8,214,391	..	9,796,000	..

Source: Statistics Canada.
^{p}Preliminary; .. Not available for publication.

pillar recovery in the same areas. The Quirke operation has demonstrated its capability to meet deliveries into the mid-1970's and the additional potential of several of the company's shut-down Elliot Lake operations ensures Rio Algom's position as a major uranium producer for the longer term.

Significant to Rio Algom's international position was the opening on October 1, 1972 of the company's Lisbon mine near Moab, Utah. The mill, which has a nominal capacity of 500 tons per day, produced some 350,000 pounds U_3O_8 from ore with an average recovered grade of 5.43 pounds U_3O_8 per ton during the final quarter of 1972. The total project cost of the Lisbon operations was (U.S.) $23.6 million or (U.S.) $39,000* per annual ton of U_3O_8.

In Saskatchewan, Eldorado continued its planned program of curtailed production, operating its 1,800 ton-a-day mill at about half capacity. A total of 203,024 tons of ore was treated, with an average recovery of 6.57 pounds U_3O_8 per ton, to produce

* Historically, capital costs in Canada's uranium industry (to 1959) averaged between $26,800 and $28,300/annual ton U_3O_8, exclusive of townsites and municipal services; all but one of 23 mines were underground mines.

Table 2. Uranium production by major producing countries, 1962-72

	Canada	United States	South Africa	Other[1]	Australia	France[2]	Total[3]
			(short tons U_3O_8)				
1962	8,430 $158,183,669	17,010	5,024	80	1,300	2,603	34,447
1963	8,352 $136,909,119	14,218	4,532	86[4]	1,200	2,692	31,080
1964	7,285 $ 83,509,429	11,847	4,445	144	370	2,113	26,204
1965	4,443 $ 62,361,377	10,442	2,942	179	370	2,210	20,586
1966	3,932 $ 54,334,787	9,587	3,286	162	330	2,223	19,520
1967	3,738 $ 53,021,936	9,125	3,214	273	330	2,272	18,952
1968	3,701 $ 52,284,580	12,570^r	3,883	289^r	330	2,234^r	23,007^r
1969	3,854 $ 53,150,657	12,281^r	3,979	332^r	330	2,306^r	23,082^r
1970	4,104 ..	12,768	4,119	335^r	330	2,202^r	23,858^r
1971	4,107 ..	12,907	4,189	340	115[5]	2,836	24,494
1972^p	4,898 ..	13,300	4,000	350	0	2,850	25,398

Sources: Statistics Canada; U.S. Bureau of Mines, *Minerals Yearbook;* U.S. Commodity Data Summaries, January 1973; and South African Chamber of Mines *Eighty-second Annual Report, 1971.*
[1]Includes Argentina, Portugal, Spain and Sweden. [2]Includes Gabon, Malagasy Republic (until 1968) and Niger (from 1970). [3]Totals are of listed figures only. Other countries are known to have produced small quantities of uranium and estimates have been included in totals for 1964 and earlier, in tables of this series in previous reviews. [4]Estimate for Spain. [5]Estimate, production ceased April 1971.
^{p}Preliminary; ^{r}Revised; .. Not available for publication.

1,334,647 pounds of U_3O_8. Output from the company's Hab mine, located some 7 miles northeast of the main Fay complex, increased throughout the year so that it accounted for 41 per cent of the year's production. The higher grade of the Hab ore, together with higher mill recoveries achieved as a result of the conversion of pachucas to mechanical agitation in 1971, resulted in a 7.6 per cent reduction in operating costs per pound U_3O_8.

Development continued to tap downward extensions of the Fay orebodies, with the sinking of the internal Fay shaft, which was expected to be completed in early 1973. Surface and underground substation equipment for the shaft was installed and construction of a new mine heating and ventilation plant was completed. In addition, new pollution control and effluent treatment facilities were installed, as planned, to comply with more stringent regulations.

Gulf Minerals Canada Limited proceeded with development work at its Rabbit Lake property, near the southwestern end of Wollaston Lake, northern Saskatchewan. Activities consisted of the construction of foundations, some site preparation and the installation of temporary warehouse and maintenance facilities. Although Rabbit Lake had been partly drained to expose the orebody, completion was pending final plans for the waste disposal area; actual stripping of the orebody, most of which will be mined by open pit methods to a depth of about 400 feet, is scheduled for 1974. Construction of the mill, capacity 4.5 million pounds U_3O_8 per year, will begin in 1973 with first production scheduled for 1975. The total project cost is estimated at $50 million*, to be financed 49 per cent by Gulf's West German partners, Uranerz Canada Limited.

The Saskatchewan government continued with the construction of an all-weather highway to the Gulf project, which will extend 150 miles from the southern tip of Reindeer Lake; completion is scheduled for 1974. Gulf is presently considering instituting an air-bus service to provide transportation for mine employees from established communities in northern Saskatchewan. Under the plan, employees would live in bachelor quarters at the mine during a compressed work period, commuting to their homes for several days off. The plan is seen as an effective way both to decrease manpower turnover and to employ Indians located in various outposts in northern Saskatchewan.

Exploration and reserves

Uranium exploration activity in Canada in 1972 was minimal, lower than for any year since the hiatus of the late 1950's and early 1960's. By year-end only three new uranium exploration permits had been issued by the Atomic Energy Control Board (AECB), and revocation of some 21 permits had been granted, leaving only about 52 permits in force, of which well over half were inactive.

* $22,200 per annual ton U_3O_8.

Table 3. Estimates of uranium reserves and resources in Canada

Price[1] Category	Reasonably Assured Resources[1]		Estimated Additional Resources[1]	
	at 1/1/70	at 1/1/73	at 1/1/70	at 1/1/73
	(short tons U_3O_8 x 1,000)			
($/lb U_3O_8)				
up to 10	232	241	230	247
10 to 15	130	158	170	284

[1]NEA/IAEA classifications: reasonably assured resources in up to $10 category are defined as *reserves.*

Perhaps the only significant Canadian developments were those made known by Mokta (Canada) Ltée in late 1972. Although it had been rumoured for some time, the company confirmed that it had outlined a small but rich uranium orebody at Cluff Lake in the Carswell dome area of northern Saskatchewan. Mokta has control of some 200 square miles in the area and has been spending about $1 million per year recently examining uranium showings associated with the Carswell structure. The main mineralization is massive, of the pitchblende-replacement type, and occurs at the contact of the Athabasca sandstone and the basement. The Saskatchewan government was building a 146-mile winter road from Turnor Lake to Cluff Lake, which was expected to be completed in early 1973.

A reassessment of Canada's uranium reserves and resources was completed in 1972 by the Department of Energy, Mines and Resources. A summary* appears in Table 3, together with earlier figures published in 1970. While the net increase in *reserves* (after production) and the increase in estimated additional resources in the same price category (up to $10/lb) are due partly to a reassessment of all known districts, they are due largely to discoveries and developments in northern Saskatchewan over the interval and the consequent improvement in uranium potential for this province. In the case of the resource estimates for the higher price category, the increases are primarily a result of the extension of geological knowledge in all 'known uranium districts' and the consequent reassessment of estimates for these areas.

Exploratory activity has also declined in the United States, where exploration and development drilling for uranium declined to 15.4 million feet in 1972, down 49 per cent from the peak in 1969.

* For a more detailed account see Williams, R.M., and Little, H.W., Canada, in *(World) Uranium Resources, Production and Demand* NEA/IAEA Working Party on Uranium Resources, OECD, Paris, in press; and Little, H.W., Uranium Deposits in Canada – Their Exploration, Reserves and Potential, paper presented, CIM Annual Meeting, Vancouver, April 1973.

Further declines were predicted for 1973. Moreover, although United States uraniun *reserves* (available at a maximum *forward cost* of \$10 per pound U_3O_8) increased by 11 per cent during 1971, the annual net increase in 1972 (to 337,000 tons U_3O_8) had dropped to 2 per cent. Indeed, in its \$8 per pound U_3O_8 *cost category* the United States Atomic Energy Commission (USAEC) reported a zero net increase in *reserves*. All additions to *reserves* have been in established districts. It is perhaps pertinent to note that there is a lag of one or two years between drilling and the reflection of the results in changes to *reserves*.

In contrast to Canada and the United States, uranium exploration in Australia was at a record high with more than 80 companies active in a number of areas; interests from several countries were represented, including Canada, France, Italy, Japan, United States and West Germany. The most active area was the Alligator Rivers uranium field in the Northern Territory where discoveries were made in 1970 by Queensland Mines Limited (Nabarlek deposit), Peko-Wallsend Ltd. (Ranger deposits), and Noranda Australia Ltd. (Jim Jim deposit). These deposits are of the pitchblende-replacement type and occur in Lower Proterozoic rocks immediately below the unconformably overlying Carpentarian volcanics and sediments; they are amenable to open pit production. Development work was proceeding on all three properties and sales announcements made by the former two companies indicate that production could begin as early as 1976 or 1977. Other programs were under way in the area and at least two companies announced that uranium mineralization had been located.

Activity also continued in the Westmoreland area in Queensland and in the Mt. Painter/Lake Frome area of South Australia. Western Australia was also the scene of considerable activity where, in early 1972, Western Mining Corporation Limited announced that significant uranium mineralization had been found over an extensive area near Yeelirrie, some 410 miles northeast of Perth. In November, the company announced that its program had established indicated reserves of about 46,000 metric tons U_3O_8. The deposits are shallow and flat-lying, occurring in 'calcrete', with average grades of 0.13 per cent U_3O_8. A discovery was also announced late in 1972 at Mundong Well, Western Australia, some 600 miles north of Perth.

As a result of activities over the past two or three years, Australia's reasonably assured resources, available at up to \$10 per pound U_3O_8, were increased to 92,000 tons U_3O_8*, over 75 per cent of which are in the Northern Territory. In 1971, South Africa's Atomic Energy Board announced an increase in its uranium resources, in the same category, to 300,000 tons U_3O_8. These two increases, together with United States (and Canadian) additions, indicated that world uranium *reserves* at year-end were about 1,100,000 tons U_3O_8, up 30 per cent from the figure reported by the ENEA/IAEA* in September 1970, and over 75 per cent from that first reported by the ENEA in August 1965. These additions (including production) average only some 85,000 tons of U_3O_8 per year over the eight-year period.

* Australian Atomic Energy Commission, June 1972.

Refining

A variety of refined uranium products was produced in 1972 at Eldorado's Port Hope, Ontario, uranium refinery. Production of uranium hexafluoride (UF_6)**, its principal product, continued on a curtailed production schedule (ten days on, four days off) instituted in late 1971 because of slippages in customers' reactor programs. Several processing steps were improved, resulting in increased conversion efficiency, and design work proceeded toward eventual expansion of the UF_6 plant from its existing capacity of 2,750 tons to 5,000 tons U per year. During the year deliveries of UF_6 (much of it converted on a toll basis) were made to utilities in Japan, United States, Germany and Sweden.

The demand for *natural* ceramic uranium dioxide (UO_2) for the fuelling of CANDU reactors continued to increase during the year and new production records were set. Both the original batch-type circuit and the continuous circuit installed in 1970 were in use for most of the year. The production of *enriched* ceramic UO_2, involving a variety of enrichments, also set new records; this was all custom work using UF_6 enriched in the United States. The company also produced a variety of high-density nuclear fuels for reactor experiments, including a major order of uranium carbide for a replacement core of one of Atomic Energy of Canada Limited's (AECL) research reactors.

Government affairs

In June 1971, the federal government formed the new Crown Company, Uranium Canada, Limited (UCAN), to act as agent on its behalf for the acquisition and future sales of the joint uranium stockpile established earlier in the year by agreement between the federal government and Denison. Subsequently, UCAN's role was broadened to give it authority over future sales from the general government stockpile. In November 1972, it was announced that the entire joint-venture stockpile and part of the general stockpile will be marketed through a sale to Spain (see Markets).

In August 1972, the Minister of Energy, Mines and Resources issued a directive to the Atomic Energy Control Board respecting minimum selling prices and volumes of sales to export markets to be considered in the granting of uranium export permits. The directive was made in an effort to stabilize the current uranium

* European Nuclear Energy Agency/International Atomic Energy Agency. ** UF_6 is used as feedstock for both the gaseous diffusion and centrifuge uranium enrichment processes.

marketing situation and to promote the development of the Canadian uranium industry. All other aspects and implications of export contracts will continue to be examined by the Board, prior to the granting of export permits, as outlined in the Minister's policy statement of June 19, 1969.

In February 1972, Canada signed an agreement with the International Atomic Energy Agency (IAEA) providing for IAEA inspection of Canadian nuclear installations. The safeguard inspections will not extend to the mining and milling stage of the uranium industry, but will begin at the 'product-output' stage of uranium refining. Canada is the first 'near-nuclear weapon' state to enter into an IAEA safeguards agreement, as required under the terms of the Non-Proliferation Treaty (NPT). Canada was one of the first countries to ratify the NPT, thus reaffirming its policy that Canadian uranium be used only for peaceful purposes.

In October 1972 the Government of Canada agreed to make loan funds available to assist in the financing of a 600 MWe nuclear electric station Hydro-Quebec proposes to build at Gentilly on the south shore of the St. Lawrence River, near Trois-Rivières. The plant, tentatively named Gentilly 2, would be adjacent to the prototype Gentilly Nuclear Power Station. Through Atomic Energy of Canada Limited (AECL), the federal government will provide up to 50 per cent of the financing for the station, the cost of which is estimated at $300 million. The loan will be repaid, with interest, over 25 years from the date the plant is declared in service. The target is to have the station ready for full power operation in early 1979. In agreeing to assist in the financing of Quebec's first commercial nuclear power station, the federal government is observing the same principle of co-operation that was applied when it undertook to participate in the financing of Ontario's first commercial nuclear plant, at Pickering. Through AECL, the Government of Canada underwrote 35 per cent of the capital cost of the first two units of the four-unit Pickering station. The amount involved was approximately $150 million.

Enrichment*

There was considerable manoeuvring on the international scene as various countries and interests became more deeply involved in studying the many questions relating to the construction of the world's next major uranium enrichment plant. In the United States, in February 1972, representatives of 21** domestic companies met with officials of the United States Atomic Energy Commission (USAEC) for a series of technical briefings and tours as the first step in the USAEC's domestic access program on uranium enrichment technology. Subsequently, 17 of these companies notified the USAEC of their intention to submit proposals toward programs in *research and development of technology for enriching uranium and for manufacturing enrichment systems equipment.* By the November 30 due date, however, only seven companies actually submitted proposals. The USAEC had hoped to choose ten companies to participate in the second step of this R and D oriented access program.

In December, the USAEC took a further step in its efforts to encourage the private sector to develop the new enrichment capacity needed in the 1980's by announcing proposed regulations for access by domestic companies to technology for use in *the design, construction and operation of facilities to enrich uranium.* It was also indicated that the USAEC did not intend to build additional enrichment capacity beyond the planned 'Cascade Improvement' and 'Uprating Programs' to its existing plants. By year-end two possibilities of a United States commercial enrichment venture had emerged. The Reynolds Metals Company had submitted a proposal under which it would form a consortium to build, own and operate a gaseous diffusion enrichment plant near Buffalo, Wyoming, based on the company's coal reserve of 2,000 million tons and water rights in the area. In addition, Westinghouse Electric Corporation, Bechtel Corporation and Union Carbide Corporation were also considering a joint-venture enrichment enterprise, possibly in co-operation with Japanese interests.

Little was reported further to the USAEC's late 1971 meeting with representatives of 13 countries on possible foreign access to its gaseous diffusion technology, although it appeared likely that the first new plant to be based on U.S. technology would be built in the United States by the private sector. In this regard, in September, Japan signed an agreement to study a possible United States – Japan enrichment joint venture. Earlier, Japan signed similar agreements with France and Australia, in January and March, respectively, for the possible location of a diffusion plant in the Pacific area based on French technology. In Canada, Brinco Limited continued its feasibility study on the possibility of building an enrichment plant. The Canadian government co-operated with Brinco in the exchange of ideas, in an effort to formulate guidelines within which private industry could explore the commercial viability of establishing an enrichment complex in Canada.

In Europe, in March, industrial and state-owned companies of five nations (Belgium, Britain, Italy, Netherlands and West Germany) joined France for a projected two-year economic feasibility study (designated EURODIF) of a 6 to 7 million separative work unit (SWU) per year diffusion plant, located in

* For background see 1970 Mineral Review No. 51 and 1971 Mineral Review No. 50, Uranium and Thorium, Mineral Resources Branch, Department of Energy, Mines and Resources. ** Originally 22 companies were to take part in the step; one company withdrew at the last moment.

western Europe. Late in the year, Sweden and Spain also joined the EURODIF project. The European Economic Community (EEC) also proposed, in mid-1972, that a joint governmental-industrial European enterprise be set up to study the enrichment situation (including both the diffusion and centrifuge technologies) and, subsequently, to move toward developing enrichment capacity in Europe under joint administration.

Centec GmbH, one of the two companies* set up under the 1970 British-Dutch-West German Tripartite Agreement, proceeded with the design of a 300,000 SWU per year centrifuge enrichment plant which it intends to order in the second half of 1973; production is scheduled for 1976. Centec and the other company, The Uranium Enrichment Company Ltd. (Urenco), also laid plans for merging the research and development efforts of the three countries into a single integrated program beginning in 1973, to be financed by the two companies with subsidies from the three governments on a declining scale. Meanwhile, the three national pilot plants were in various stages of construction and commissioning. Urenco hopes to have 2 to 3 million SWU's per year of annual capacity installed by 1980 and at least 10 million SWU's per year by 1985. At year-end, the troika set up a 'study association' to make classified information on the gas centrifuge process available to outside agencies and enterprises interested in examining the economic, technological and organizational possibilities for establishing additional centrifuge enrichment capacity.

Of considerable significance to the world enrichment situation, was the USAEC's announcement on March 7, 1972 that it plans to continue operating its enrichment plants, after June 30, 1973 with a tails-assay of 0.275 to 0.30 per cent U^{235} rather than the 0.20 per cent U^{235} used as a basis for transactions with enrichment customers. The plants have been operating at a tails-assay of 0.30 per cent since July 1, 1971. The higher tails-assay will require additional uranium feed, which will be supplied from the USAEC surplus uranium stockpile (see also Markets). Contracts with enrichment customers, however, will continue to be on the basis of a 0.20 per cent tails-assay. Under this arrangement, customers will provide less feed to produce their enriched uranium requirements at the higher operating tails-assay, but will pay for more SWU's than actually used in producing their enriched product; part of the cash payment will constitute payment to the USAEC for such additional feed that it supplies from its stocks. The effect of the arrangement is to decrease the requirement for separative work, allowing the USAEC to further build its inventory of enriched uranium, thus enabling the existing plants to meet the demand for enriched uranium until a later date and deferring the time (by about a year) when new enrichment capacity will be needed. The industry had earlier been advised to plan for a tails-assay of 0.25 per cent U^{235} for transactions after fiscal year 1973.

Also of considerable impact to enrichment customers in the United States, Europe and Japan was the December 1972 announcement of the USAEC that it was working toward a revision of its contracting procedures for enriching services and that it would not enter into further contracts until the review was completed; the results of its review were made known the following month. Under its proposed new criteria, future contracts would have to be signed eight years in advance of first deliveries and would be for a minimum of ten years. When signing a contract, a downpayment would have to be made equivalent to a third of the total value of the services required for the first fuel core ($3.3 million for a 1,000 MWe reactor). Notice of termination of a contract would be required 10 years in advance and penalty charges would range from 50 to 75 per cent of the total contract. Finally, the new contracts would no longer guarantee the customer a maximum charge per unit of enriching services. However, the unit charges would be less than for the existing type of contracts, thus reflecting the lesser financial risk to the USAEC under the new type of contracts.

Markets

In November 1972, Denison and UCAN confirmed a sales agreement valued at nearly $60 million, involving 8.9 million pounds of U_3O_8 destined to a group of Spanish utilities over the period 1974 to 1977. The sale will completely dispose of the 3,200-ton U_3O_8 joint-venture stockpile being accumulated by the companies during 1971 to 1974, and also a portion of the federal government's general stockpile. This development brought total Canadian uranium commitments made since 1966 to over 73,000 tons U_3O_8, an estimated 9,500 tons of which had been delivered by year-end. The final delivery under the 'master' contract (1962 UKAEA option) was made in February.

Internationally, market activity was relatively brisk in 1972 with several sales being confirmed, notably by Australian companies with Japanese utilities. Queensland Mines Limited and Ranger Export Development Co. Pty Ltd.* shared some 7,000 tons U_3O_8 of new Japanese business for periods variously reported between 1976 and 1986, and Mary Kathleen Uranium Limited boosted its sales by some 30 per cent to a total of almost 5,000 tons U_3O_8. Two major sales were reportedly consummated by RTZ Mineral Ser-

* Owned in equal shares by the three parties; *Centec* is responsible for co-ordinating the integrated centrifuge research and development program, designing and building centrifuges and constructing enrichment plants, while *Urenco* will purchase plants from Centec, operate them through subsidiaries and market the enriched uranium.

* A company set up to market uranium on behalf of Peko-Wallsend Ltd. and Electrolytic Zinc Company of Australia Ltd. from the Ranger property.

vices Limited of London with Tokyo Electric Power Co. Inc. and Kansai Electric Power Co., Inc. of Japan for 8,900 and 8,200 tons U_3O_8, respectively, for delivery (probably from Southwest Africa's Rossing deposit) over 10-year periods beginning in 1976 or 1977. Some 7,600 tons U_3O_8 of additional business between RTZ and Japanese customers was in various stages of negotiation. Finally, URANEX of France and Nuclear Fuels Corporation of South Africa (Pty) Ltd. (NUFCOR) reportedly had some 6,200 tons U_3O_8 of new Japanese contracts either confirmed or under negotiation.

Forward commitments of United States producers, as of January 1, 1973, totalled 86,300 tons of U_3O_8 to United States customers and 2,100 tons of U_3O_8 to foreign customers. These contracts are largely short-term and, significantly, the percentage of United States nuclear generating capacity for which fuel arrangements have been made has declined from previous years. Although it was difficult to document world contract data with any degree of certainty, open literature suggested that as of January 1,1973, forward commitments to 1985 total at least 200,000 tons U_3O_8, or about 20 per cent of projected requirements to that time. In view of the paucity of published data on European contracts in particular, this is undoubtedly less than the real figure. Moreover, France's domestic requirements will be supplied from its own production and no specific supply arrangements have appeared in open literature. However, much of the above mentioned commitments is to Japan, representing almost 80 per cent of its requirements to 1985.

Lack of available markets in the early 1970's continued to plague world producers, and surplus inventories and production capabilities provided existing producers with little incentive to initiate expansion plans in the near future. Indeed, one producer, West Rand Consolidated Mines, South Africa's only primary uranium producer, stopped production in early 1972 until market opportunities improve. There were indications, however, that uranium prices had stabilized in the low \$6 per pound U_3O_8 range for deliveries in the early 1970's particularly in the United States. Indications are that prices will increase to the range of \$7 to \$8 per pound U_3O_8 for deliveries in the mid-1970's and probably approach \$10 per pound U_3O_8 by the end of the decade.

Of particular interest was the move by the Tennessee Valley Authority (TVA), the largest utility in North America, to enter the exploration field to assure its long-term supplies. For \$2 million, TVA bought a 20 per cent interest in some of American Nuclear Corp's mineral rights in Wyoming, with options to increase this interest to 50 per cent. Also noteworthy was Carolina Power and Light Co.'s lease of uranium reserves from Federal-American Partners also in Wyoming; the utility will pay the producer the cost of production plus \$2 per pound for up to 12 million pounds of U_3O_8.

Of significance to the world uranium surplus situation was the USAEC's March 1972 announcement (see Enrichment) that it will dispose of its stockpile of 50,000 tons U_3O_8 surplus uranium by using the split-tails approach in the operation of its enrichment plants. This plan will provide for gradual disposal of the stockpile, between 1973 and 1982, without direct government competition in the private uranium market, contrary to the original intention announced in

Table 4. Exports of uranium concentrates from Canada, 1962-72

	United States	Britain	West Germany	Japan	Others	Total
			(thousands of dollars)			
1962	149,165	16,598	206	40	–	166,009
1963	96,879	40,509	–	130	13[1]	137,531
1964	34,863	39,627	159	4	–	74,653
1965	14,749	38,948	–	–	–	53,697
1966	13,761	22,605	–	–	–	36,366
1967	1,047	22,772	–	55	–	23,874
1968	3	26,064	–	–	–	26,067
1969	477	14,997	5,469	3,564	–	24,507
1970	17,031[2]	8,990	–	–	–	26,021
1971	6,213[r2]	11,473	–	1	–	17,687
1972[p]	23,042[2]	16,456	–	–	–	39,496

Source: Statistics Canada, exports of radioactive ores and concentrates that cleared customs.
[1]Brazil. [2]Almost entirely destined for a third country, following enrichment, primarily West Germany and Japan.
[p]Preliminary; – Nil; [r]Revised.

October 1971. Depending on what assumptions are used, it can be calculated that United States enrichment customers will pay between $8 and $11 per pound of U_3O_8, for the extra uranium feed that the USAEC provides under this policy. The March announcement also indicated that the USAEC does not intend to remove its restrictions on the enrichment of foreign uranium intended for domestic use until late in the decade, probably 1978.

Nuclear power developments

New nuclear plant orders in the United States in 1972 totalled some 38,000 MWe, exceeding the previous peak year in 1967 by about 50 per cent. A similar surge in orders was seen in Europe, bringing total planned nuclear capacity in the world by year-end well within reach of the 272,000 MWe now forecast for the year 1980. About half of this installed capacity will be in the United States, almost a third in western Europe and about 12 per cent in Japan; Canada's installed nuclear capacity in 1980 is expected to be about 6,100 MWe.

1972 was exceptionally good for Canada's nuclear power program. The first and second 508 MWe units of Ontario Hydro's Pickering Nuclear Generating Station continued to operate successfully and the third unit went critical on April 24, 1972, reaching full power output only 17 days later. This achievement set a world record and made the Pickering Station the largest nuclear power complex operating (with 1524 MWe net) in the world at that time. During January 1973, the capacity factors for the three units were 99.5, 97.2 and 99.9 per cent, and the station supplied almost 20 per cent of the total electrical energy used by Ontario Hydro; the installed nuclear capacity for Ontario Hydro at year-end was 1754 MWe (net), about 13 per cent of its total installed capacity, making it one of the leading nuclear utilities in the world. Unfortunately, Pickering's exceptional performance was interrupted during the latter part of the year by labour difficulties, with the consequent loss of four months' valuable operating experience, so important to Canada's nuclear power marketing effort.

Ontario Hydro's two other nuclear plants – the 208 MWe Douglas Point Station and the 22 MWe

Table 5. Nuclear power reactors in the world as of July 1, 1972

	Operating	Ordered	Planned	Total
		(net electrical megawatts)		
Argentina	–	319	600	919
Austria	–	694	–	694
Belgium	11	1,650	–	1,661
Brazil	–	600	–	600
Bulgaria	–	800	–	800
Canada	2,065	3,576	1,800	7,441
Czechoslovakia	112	840	–	952
Finland	–	840	–	840
France	2,703	3,870	–	6,573
West Germany	2,315	9,500	1,200	13,015
East Germany	70	1,530	–	1,600
Hungary	–	880	–	880
India	380	808	–	1,188
Italy	–	840	–	840
Japan	1,677	9,565	566	11,808
Korea	–	564	–	564
Mexico	–	–	600	600
Netherlands	55	450	–	505
Norway	25	–	–	25
Pakistan	125	–	–	125
Spain	600	5,025	6,260	11,885
Sweden	600	6,730	–	7,330
Switzerland	350	656	5,035	6,041
Taiwan	–	1,208	–	1,208
United Kingdom	5,432	6,456	–	11,888
United States	9,165	100,219	12,600	121,984
U.S.S.R.	3,150	5,600	–	8,750
Total	28,835	163,220	28,661	220,716

Source: Canadian Nuclear Association, August 1972.
– Nil.

Nuclear Power Demonstration Station (NDP) – operated successfully without incident except that they were shut down for intervals in the latter part of the year (a total of 9 months and 7 months, respectively) to loan their heavy water to the Pickering Station, to permit planned maintenance programs and because of the strike mentioned earlier. Construction at Ontario Hydro's Bruce Nuclear Generating Station, located at the Bruce nuclear complex near Kincardine, Ontario, proceeded on schedule. The first of four 750 MWe units is expected to go critical in the summer of 1975 with an in-service date a year later. The other three units will follow at yearly intervals.

In January 1972 the Atomic Energy Control Board (AECB) gave approval for full power operation of Hydro-Quebec's 250 MWe prototype CANDU-BLW* Gentilly Nuclear Power Station contingent on certain modifications; these were completed and full power was attained in May. The reactor was later shut down (in November) temporarily to permit the loan of its heavy water to Ontario Hydro for the Douglas Point station. In October 1972, it was announced that Hydro-Quebec would proceed with the construction of a second unit at Gentilly. It will be a 600 MWe plant of CANDU-PHW** design and is scheduled for operation in 1979 (see Government Affairs).

1972 was also significant for other reactors of CANDU design. The first of two 203 MWe units of the Rajasthan Atomic Power Project (RAPP) in India achieved criticality on August 11, 1972; after a period of commissioning and certain modifications, first power was sent to the grid in November. In Pakistan, the 125 MWe Karachi Nuclear Power Plant (KANUPP) also of CANDU design, reached full power in October; the plant went critical in August 1971, but commissioning was suspended for several months during the Indo-Pakistan conflict.

AECL's first 400-ton-a-year heavy water production unit at the Bruce nuclear complex began operation at year-end, and withdrawal of first production from the system was expected in early 1973; commissioning of the second unit was well advanced. Process steam for the plant is being supplied by an oil-fueled steam plant and by the Douglas Point station (over half the latter's output). Rehabilitation of the Glace Bay, Nova Scotia, heavy water production plant, also being carried out by AECL, was expected to be complete by the summer of 1974. Meanwhile, Canadian General Electric Company Limited's 400-ton-a-year plant at Point Tupper, Nova Scotia, operated, but only at about 60 per cent capacity because of certain feedwater chemistry problems. These were expected to be overcome during 1973, and production will increase accordingly.

The continued short-fall in total Canadian supplies of heavy water in 1972, made it necessary for AECL to arrange for the integration of several planned reactor maintenance and system change programs (Douglas Point, NPD, Gentilly, NRU and ZED-2) with a schedule of transfers of heavy water to accommodate the Pickering program. By the spring of 1974, however, Canadian heavy water supplies are expected to reach a surplus position, with the surplus growing as mature capacity is reached at the Point Tupper, Bruce and Glace Bay plants in 1975, 1977 and 1979, respectively. Despite this surplus, decisions for additional heavy water production capacity will be required before 1974. For the longer term AECL signed an agreement in 1972 with Polymer Corporation Limited for collaboration in the development of two new processes for the production of heavy water.

With the successful operating experience at Pickering, Canadian efforts to market the CANDU-PHW system abroad intensified. A tender for a 600 MWe station was submitted in June to the Comision Nacional de Energia Atomica of Argentina. AECL submitted the bid in partnership with Italimpianti, a well established Italian engineering company. The plant will be Argentina's second plant and is to be located at Rio Tercero in the Province of Córdoba. To facilitate the financing of this reactor the federal government announced at year-end that it was prepared to loan Argentina $130 million toward the Canadian content of the project.

Outlook

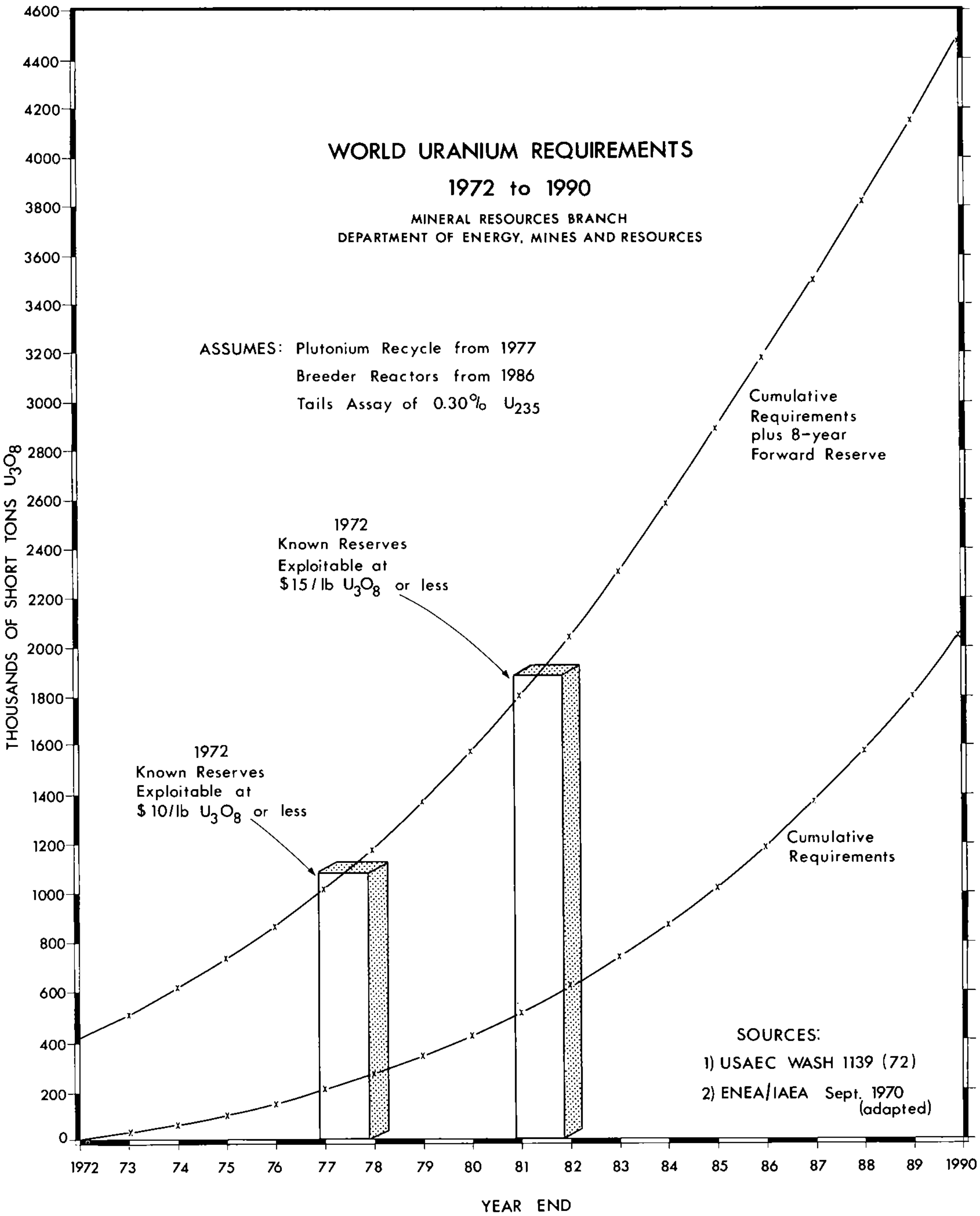
The 1972 surge in world nuclear plant orders can be attributed to several factors including increased costs and shortages of fossil fuels, the cyclical nature of utility plant orders, and the longer lead-times necessary to overcome construction and licensing delays. The present economic advantage of nuclear plants over fossil-fueled plants is likely to continue and, indeed, more and more utilities are expected to turn entirely to nuclear plants for their future base-load capacity. It is expected that electricity will provide about 50 per

Table 6. Forecast of world[1] nuclear capacity

	Range[2]		
	Low	Most Likely	High
	(net electrical megawatts)		
1973	41,200	50,100	55,600
1975	85,600	93,000	101,400
1980	249,600	272,100	297,300
1985	512,000	583,000	690,000
1990	866,000	1,088,000	1,306,000
1995	1,302,000	1,779,000	2,154,000
2000	1,860,000	2,660,000	3,400,000

Source: *Nuclear Power 1973-2000,* USAEC December 1, 1972 (Wash – 1139 (72)).
[1]World excludes U.S.S.R., eastern Europe and China.
[2]Range refers to rate of power growth.

* Canada Deuterium Uranium – Boiling Light Water.
** Canada Deuterium Uranium – Pressurized Heavy Water.


WORLD URANIUM REQUIREMENTS
1972 to 1990
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
ASSUMES: Plutonium Recycle from 1977
Breeder Reactors from 1986
Tails Assay of 0.30% U_{235}
Cumulative Requirements plus 8-year Forward Reserve
1972 Known Reserves Exploitable at $15/lb U_3O_8 or less
1972 Known Reserves Exploitable at $10/lb U_3O_8 or less
Cumulative Requirements
SOURCES:
1) USAEC WASH 1139 (72)
2) ENEA/IAEA Sept. 1970 (adapted)
THOUSANDS OF SHORT TONS U_3O_8
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
4400
4600
1972
73
74
75
76
77
78
79
80
81
82
83
84
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1990
YEAR END

cent of all energy consumption in the industrialized countries of the world by the year 2000 and that between 75 and 90 per cent of all new electrical generating capacity additions during the 1980's and 1990's will be nuclear. Thus in the twenty years from 1980 to 2000, installed world nuclear capacity is expected to increase tenfold.

These longer-term nuclear forecasts have actually changed little from those published in the last two years. There have been, however, some minor downward shifts in the projected uranium requirements (Table 7) because of improved power reactor characteristics, plutonium recycling which is now expected to start in the late 1970's and the USAEC's planned stockpile disposal program from 1973 to 1982. These projections will have no immediate impact on production plans in the uranium industry. Despite the slight improvement in the Canadian surplus situation and the removal of the United States stockpile from the open market, significant improvement in the supply-demand balance on a world basis will not likely be seen until after 1975. However, new production capacity beyond that which is presently planned will probably be required before 1980.

Projections of uranium requirements have a more immediate effect on the need for exploration. Accepting that the uranium industry, on a world basis, should maintain an eight-year forward reserve, it is estimated that cumulative requirements plus forward reserves will exceed known uranium reserves available at up to \$10 per pound U_3O_8 before the end of 1978. By 1990 the world industry must discover and develop over 3.0 million tons (U_3O_8) of additional reserves, unless higher-priced resources are to be relied on. To achieve this objective, annual discovery rates (averaging 85,000 tons U_3O_8 over the past 8 years) must increase threefold by the early 1980's and fourfold by 1990. Measured in terms of dollars (an estimated total of \$6,000 million) the exploration challenge is staggering. In view of the lead-times associated with exploration and development of new reserves, efforts should be made soon to expand exploration rates appreciably.

The critical nature of the uranium enrichment situation was highlighted in a report released by the Atomic Industrial Forum in October. The report concluded that, "the rate of separative work demand will exceed the rate of separative work capacity on a world basis by the end of 1977, even if the capacity of the three United States gaseous diffusion plants is increased by more than 60 per cent as presently planned and European plans for installed enrichment capacity are implemented as scheduled. However, the inventory of pre-produced separative work to be accumulated prior to 1977 can be used to stretch separative work availability until the end of 1981, by which date pre-produced inventory will be exhausted." Finally, the report stated that, "there is no way which the unacceptable consequences of a future shortfall in separative work capacity can be avoided unless plans for the first major increment in new plant capacity are initiated before the end of 1972."

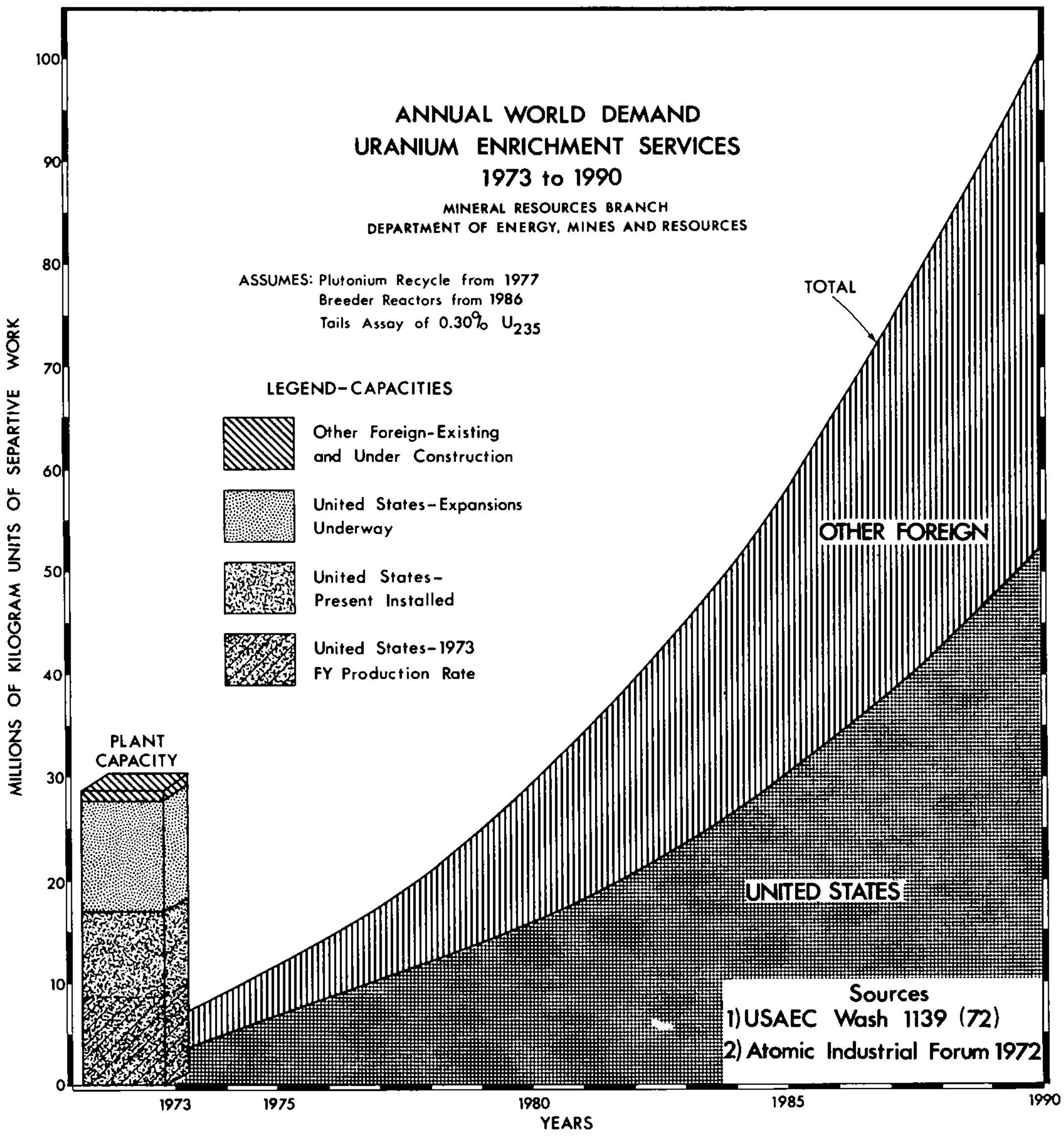
Focussing on the Canadian situation, little change in uranium production levels is anticipated until 1975 when available capacity will be increased to about 8,000 tons of U_3O_8 a year with the addition of Gulf's Rabbit Lake mine. Except for small spot-sales, there are few market opportunities evident for Canadian producers until after 1975. Moreover, little immediate increase in exploration is anticipated because of the short-term market outlook and the Canadian uranium ownership problem.

There are two factors, however, which could bring about a more rapid change in outlook for the industry than presently expected. Should results of uranium exploration in the United States for the next year or two be disappointing, its restrictions on the import of foreign uranium could be removed earlier than 1978.

Table 7. Forecast of world[1] uranium requirements

	Range[2]					
	Low		Most Likely		High	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
	(short tons U_3O_8 x 1,000)					
1973	19.5	37.0	22.4	40.0	25.1	43.0
1975	34.1	97.0	37.9	109.0	41.3	118.0
1980	72.7	384.0	81.4	423.0	92.8	465.0
1985	124.9	899.0	150.1	1,022.0	182.1	1,185.0
1990	177.8	1,687.0	248.4	2,052.0	300.2	2,433.0
1995	221.2	2,709.0	312.7	3,511.0	395.0	4,239.0
2000	251.2	3,910.0	354.8	5,202.0	464.0	6,427.0

Source: *Nuclear Power 1973-2000,* USAEC December 1, 1972 (Wash–1139(72)). Note: Enrichment plant tails-assay at 0.30% U^{235}; plutonium recycle beginning in 1977 and breeder reactors in 1986. [1]World excludes U.S.S.R., eastern Europe and China. [2]Range refers to rate of power growth.



thus helping to stabilize the world uranium market. Finally, if there should be a shift from short- to long-term purchasing policy on the part of United States and European buyers in particular, the incidence of even a few such sales would provide considerable impetus to the industry to prepare for the expected demands of the 1980's.

Table 8. Forecast of annual world[1] requirements for uranium enrichment services

	Range[2]		
	Low	Most Likely	High
	(10^3 separative work units per year)		
1973	5,100	6,300	6,500
1975	10,300	13,000	13,700
1980	26,400	29,100	32,600
1985	48,600	57,900	70,100
1990	74,600	100,500	123,100
1995	99,300	135,900	170,200
2000	113,000	158,900	207,400

Source: *Nuclear Power 1973-2000,* USAEC December 1, 1972 (Wash–1139 (72)).
Note: Enrichment plant tails-assay at 0.30% U235; plutonium recycle beginning in 1977 and breeder reactors in 1986.
[1]World excludes U.S.S.R., eastern Europe and China.
[2]Range refers to rate of power growth.

THORIUM

Thorium was not produced in Canada again in 1972. Until mid-1969, the Nuclear Products Department of Rio Algom Mines Limited had produced thorium concentrates as a byproduct of uranium at its Nordic mill in Elliot Lake, Ontario; the plant had a capacity to produce 150 to 200 tons of thorium oxide (ThO_2)* a year. Production was suspended in July 1968 with the closure of the Nordic mill. Because of poor market conditions for thorium and rare earths** a transfer of the thorium recovery circuit from Nordic to Quirke was not considered justified at that time. The last shipments of thorium concentrate from the company's inventory were made in 1969; the concentrate was a thorium sulphate ('thorium cake') and graded from 35 to 40 per cent ThO_2.

During the period of thorium production which began at Elliot Lake in March 1959, Rio Algom's principal customer was Thorium Ltd., in Britain. Small quantities were also delivered from time to time, in the form of metallurgical-grade thorium oxide (99.8+ per cent ThO_2), to Chromasco Corporation Limited (formerly Dominion Magnesium Limited), Haley, Ontario, which produced sintered pellets of pure (98 per cent) thorium and thorium powder (99.5 per cent).

Canadian resources of thorium are associated with both the conglomeratic ores of the Elliot Lake-Agnew Lake areas and the pegmatitic ores of the Bancroft area. Data compiled in connection with recent assessments of Canada's uranium reserves, made by the Department of Energy, Mines and Resources, suggests that reasonably assured resources of ThO_2, associated with uranium reserves in the category of $10 a pound U_3O_8, conservatively exceed 100,000 tons of ThO_2. Further details concerning Canada's production of thorium can be found in previous issues of this series.

Present world production of thorium is primarily as a byproduct of the chemical processing of monazite beach sands for their rare-earth content. The leading producers of monazite are Australia, Brazil, India, Malaysia and the United States. The principal non-energy uses of thorium continue to be in the manufacture of gas light mantles, of thorium-magnesium alloys and of dispersion-hardened alloys of nickel, cobalt, tungsten and molybdenum. Demand for thorium for industrial uses has changed little in recent years and, although some growth can be expected in the 1970's through new uses, is expected to remain relatively small, perhaps rising to no more than a few hundred tons a year by the end of the century.

The greatest potential use for thorium, however, is as a nuclear fuel for advanced converter and breeder-type reactors. Although thorium (Th^{232}) is not a fissile material like U^{235}, it is a fertile material and can be converted into fissionable uranium-233(U^{233}) under irradiation. The use of this '$Th^{232} - U^{233}$ fuel cycle' has many potential advantages and research programs are under way in several countries, including Canada, to develop this technology. Of particular interest as potential users of this fuel cycle are the Canadian CANDU reactor and the high-temperature, gas-cooled reactor (HTGR) being developed in the United States. A 40 MWe demonstration HTGR has been in operation at Peach Bottom, Pennsylvania since 1966 and a 330 MWe prototype HTGR is being commissioned at Fort St. Vrain, Colorado for start-up probably in 1973; the system is being developed by Gulf General Atomics Co. (GGA), the nuclear energy subsidiary of Gulf Oil Corporation. The commercial acceptance of the system was realized in 1971 with orders placed by Philadelphia Electric Company (two 1,160 MWe units, the first unit for 1980 start-up) and Delmarva Power & Light Company (two 770 MWe units, the first for 1981 start-up). In May 1972, GGA received its third commercial order from Southern California Edison Company for two 770 MWe HTGR's the first unit for 1981 start-up. The HTGR system has a net operating efficiency significantly higher than United States light-water reactors and its good environmental characteristics are viewed by some as possible aides to the reactor-licensing dilemma faced in the United States. To illustrate the potential thorium requirements of GGA's HTGR, the initial core for a 1,000 MWe unit uses 40 tons of ThO_2 and refueling (after the second year) uses 10 tons of ThO_2 per year.

Despite the advantages of the $Th^{232} - U^{233}$ fuel cycle and the probable ultimate success of the fuel technology, the growing availability of plutonium

* 1 short ton ThO_2 = 795 kilograms of thorium metal.
** Rare earths were also recovered with thorium as a byproduct of uranium; see 1972 Mineral Review No. 37, Rare Earths, by C.J. Cajka.

Table 9. Contingency forecasts of demand for thorium by end use, year 2000

End Use	1968 Demand: U.S.	1968 Demand: Rest of World	Demand in Year 2000: United States: Forecast Base	United States: Low	United States: High	Rest of World: Low	Rest of World: High
			(short tons Th)				
Power reactors	–	–	770	–	2,170	775	5,240
Gas mantles	55		125	120	140		
Aircraft alloy	33		84	72	90		
Refractories	6	88	15	13	22	265	360
Catalysts	5		14	11	20		
Dispersion-hardening alloys	5		20	11	25		
Other uses	6		22	13	33		
Total	110	88	1,050	240	2,500	1,040	5,600
				(median 1,370)		(median 3,320)	

Source: USBM *Mineral Facts and Problems,* 1970 edition.

from conventional reactors will dictate its use either for recycling or, in the 1980's as fuel (with uranium) for fast breeder reactors. Thorium-type breeders are also feasible, however, although they will have to compete with the plutonium-uranium fueled fast breeders upon which most of the breeder development work is currently concentrated.

The United States Bureau of Mines (USBM) recently published some demand forecasts for thorium to the end of the century. The forecast indicated an annual world demand range in the year 2000 of 1,280 to 8,100 tons of thorium; the cumulative requirement from 1968 to 2000 would range from 23,300 to 86,500 tons of thorium. The high forecast assumed a high penetration of HTGR's into the world nuclear power market largely because of their better thermal and air pollution control characteristics, their higher operating efficiency and their inherently safer design compared with non-thorium utilizing (enriched uranium) light-water reactors. Even with the attainment of these high range forecasts, however, the cumulative requirements to the end of the century, would use only a fraction of the world's estimated 500,000 tons* of reasonably assured low-cost ThO_2 resources.

* ENEA/IAEA, September 1970.

Vanadium

D.D. BROWN

Vanadium's largest market is the steel industry, in which this metal is consumed principally in the form of ferrovanadium. In recent years about 80 per cent of world vanadium production has been used in steel production, with alloy steels and high-strength low-alloy (HSLA) steels accounting for the largest end-use consumption. The weak vanadium market in 1971, which reflected a major downturn in world steel production, showed signs of recovery with improved demand and moderate firming of prices in the second half of 1972. A strong upward trend in world steel demand indicated for 1973 should result in continued improvement in vanadium demand. The principal vanadium-producing noncommunist world countries are the Republic of South Africa, the United States, South-West Africa, Norway and Finland. World production of vanadium in ores and concentrates in 1972 was an estimated 24,570 short tons.

The increase in world vanadium production of nearly 7 per cent annually since 1962 has resulted largely from the development and production of HSLA steels. The two applications that have resulted in increased use and which hold particular promise for expanded HSLA markets are in structural steel and pipeline steel. Long-term growth in demand for vanadium is projected at about 5 per cent annually, a rate of increase that is approximately the same as world iron and steel production. World reserves of vanadium-bearing ores are sufficient to meet long-term demand and entry of other producing firms with large-scale plants would add substantially to existing capacity. World consumption is currently small compared with potential production. Large-scale new production could bring supply pressure on market prices unless world consumption increases more rapidly than envisaged or new uses are developed.

The vanadium-bearing titaniferous magnetite ores of the Bushveld complex in the Transvaal, South Africa, are expected to be the largest vanadium source in years ahead. Byproduct vanadium from crude oil and tar sands could supply a significant part of future world supply as increased environmental controls increase the availability of fly ash from various fossil fuel residues.

Vanadium was recovered in Canada during 1972 in the form of vanadium pentoxide at Masterloy Products Limited's plant in Gloucester Township, near Ottawa, Ontario. The Masterloy vanadium-recovery plant has processed petroleum residue fly ash from the thermoelectric power stations and from sodium fluorovanadate, which is precipitated from the Aluminum Company of Canada, Limited's bauxite leaching circuit at its alumina plant at Arvida, Quebec. Ferrovanadium is produced by aluminothermic reduction of vanadium pentoxide at Masterloy Products Limited's ferroalloy plant.

During 1971, Canada's imports of ferrovanadium of 99 tons (gross weight) represented about 27 per cent of domestic ferrovanadium consumption, which totalled 368 tons.

Canadian developments

A pyrometallurgical process has been developed by the Mines Branch, Department of Energy, Mines and Resources, Ottawa, to recover vanadium and nickel contained in fly ash obtained from Athabasca tar sands bitumen in northern Alberta. The fly ash is produced by combustion of petroleum coke obtained from tar sand bitumen, which is used as a fuel for boilers at the Great Canadian Oil Sands Limited's (GCOS) oil production plant, Fort McMurray, Alberta. Mines Branch laboratory tests indicated that clean fly ash from GCOS contained an average of 2 per cent vanadium and 1 per cent nickel; the tar sand bitumen contains about 150 parts per million vanadium. It is expected that vanadium and nickel recovery may be economically feasible when synthetic oil facilities process tar sands to recover perhaps more than 200,000 barrels of synthetic crude a day; GCOS produces about 2,800 tons of petroleum coke a day and burns about 2,000 tons a day. It processes about 120,000 tons of tar sands a day from which it recovers some 60,000 barrels of synthetic crude.

Foreign developments

United States. United States production of vanadium continued to decline and was an estimated 5,000 short tons of contained vanadium in 1972 compared with 5,252 tons in 1971. Peak U.S. production, achieved in 1968, was 6,483 tons. U.S. production statistics by areas are withheld but the downward trend is the result of reduced byproduct vanadium output from the declining uranium mining industry in the Uravan belt of the Colorado Plateau region. Consumption in 1972 increased to 5,091 tons of vanadium compared with 4,700 tons in 1971 and 5,134 tons in 1970. Exports of ferrovanadium continued to decrease and were 269 tons (gross weight) in 1972, compared with

Table 1. Canada, vanadium imports and consumption, 1971-72

	1971 (short tons)	1971 ($)	1972^p (short tons)	1972^p ($)
Imports, ferrovanadium				
Austria	36	276,000	60	326,000
Britain	21	97,000	31	131,000
Belgium and Luxembourg	–	–	22	115,000
United States	42	223,000	3	13,000
Total	99	596,000	116	585,000
Consumption, ferrovanadium				
Gross weight	368	..	..	..
Vanadium content	268	..	..	..

Source: Statistics Canada.
^{p}Preliminary; – Nil; . . Not available.

676 tons in 1971. Exports of vanadium in ore, concentrates, pentoxide, oxide and vanadates also decreased substantially to 176 tons from 260 tons in 1971. Imports consisted of 574 tons (gross weight) of ferrovanadium compared with 68 tons the previous year. The United States is expected to become increasingly dependent on vanadium imports.

United States production of vanadium pentoxide (V_2O_5) in 1972 took place at four recovery plants: the Union Carbide Corporation plant at Rifle, Colorado, recovered vanadium as a byproduct of uranium-vanadium ore produced in the Colorado Plateau area; Union Carbide also recovered vanadium as a primary product from its vanadium-bearing clay mining operation at its Wilson Springs plant in Arkansas; Kerr-McGee Corporation, with a recovery plant at Soda Springs, Idaho, recovered vanadium from ferrophosphorus obtained as a byproduct from electric-furnace smelting of phosphate rock to elemental phosphorus; Susquehanna-Western Inc. recovered vanadium at its plant at Edgmont, South Dakota.

In May, the United States government General Services Administration (GSA) sold its total authorized excess stocks of vanadium pentoxide amounting to 5.6 million pounds averaging about 88 per cent vanadium pentoxide. The material was sold on contract to three metal-trading firms with deliveries staggered over periods of one to two years and at prices ranging from $1.148 to $1.180 a pound. The GSA made no further sales or offerings of vanadium during the remainder of the year. As of December 31, 1972 the United States government's inventory included 2,069 short tons of vanadium pentoxide (383% of objective) and 1,200 short tons of ferrovanadium (objective zero). The stockpile objective was reduced to 540 short tons of contained vanadium in 1970.

Republic of South Africa. The Republic of South Africa produced an estimated 4,340 tons of vanadium pentoxide in 1972 compared with 4,411 tons in 1971. During the fiscal year ended June 30, 1972, the Vantra Division of Highveld Steel and Vanadium Corporation Limited produced 31,007 short tons of vanadium slag compared with 31,670 tons in the previous fiscal year. Production in the second half of 1972 was 16,848 short tons of vanadium slag. Vanadium pentoxide output at Highveld was lower than in the previous fiscal year because of a weak vanadium market. The slag, which contains about 25 per cent vanadium pentoxide, is produced as a coproduct with electrically smelted molten iron from titaniferous magnetite ore. The Highveld production facility, near Witbank in eastern Transvaal, has a rated capacity of 480,000 tons a year of pig iron and 23 million tons a year of vanadium pentoxide in slag. The magnetite ore processed in 1972 was drawn from the Mapochs mine where proven reserves are estimated at 20 million tons of ბpen-pit ore grading 56 per cent iron, 13 per cent TiO_2 and 1.4 to 1.9 per cent V_2O_5. It currently accounts for about one sixth of the 120-million-ton reserve available to Highveld. In March 1973, Highveld announced an expansion project under way to result in a 25 per cent increase in its vanadium slag and steel output. The additional slag output will be exported.

Table 2. World production of vanadium in ores and concentrates, 1969-72

	1969	1970	1971	1972^e
	(short tons)			
Republic of South Africa	6,159	8,099	8,350	8,500
United States	5,577	5,319	5,252	5,000
U.S.S.R.	3,051	3,377	3,500	..
Finland	1,484	1,450	1,222	..
Norway	1,110	1,190	1,160	..
South-West Africa	500	660	650	..
Chile	600	610	660	..
France	100	100	100	..
Other	–	–	–	11,070
Total	18,581	20,805	20,894	24,570

Sources: U.S. Bureau of Mines, *Minerals Yearbook*, Preprint 1971; U.S. Commodity Data Summaries, January 1973, for 1972.
^{e}Estimated; . . Not available.

Table 3. Vanadium consumed in the United States, 1971-72

	1971	1972
	(pounds of vanadium)	
Ferrovanadium	8,180,911	8,818,379
Oxide	218,340	282,029
Ammonium metavanadate	71,347	93,943
Other	903,081	988,513
Total	9,373,679	10,182,864

Source: U.S. Bureau of Mines, Mineral Industry Surveys.

Table 4. Vanadium consumed in the United States by end-use, 1971-72

	1971	1972[p]
	(short tons of vanadium)	
Steel		
High-speed tool	441	620
Stainless	30	29
Alloy (excluding stainless and tool)	2,530	3,013
Carbon	830	827
Other steel	–	–
Cast iron	56	38
Welding and hardfacing rods and materials	10	10
Nonferrous alloys	370	352
Chemical and ceramic uses	114	102
Miscellaneous and unspecified	421	100
Total	4,802	5,091

Sources: U.S. Bureau of Mines: *Minerals Yearbook*, Preprint for 1971 and Mineral Industry Surveys for 1972.
[p]Preliminary; – Nil.

Finland. Rautaruuki Oy, the state-controlled organization involved in mining and processing Finland's ferrous metals, produced 2,177 short tons of vanadium pentoxide in 1971 at its Otanmaki titaniferous magnetite mine. The company's second vanadium producer, the Mustavaara mine near Ulleaborg, will be developed for production of 3,000 tons of vanadium pentoxide a year starting in 1974-75.

Products and uses

Vanadium is used principally as an additive in the steel industry in the form of ferrovanadium and other vanadium ferroalloys. Its function is to reduce and control grain size, to impart toughness, strength, and impact resistance, and to maintain hardness at elevated temperatures. Vanadium-bearing, high-strength, low-alloy steels (HSLA) and alloy steels account for about 55 per cent of total consumption. HSLA steels usually contain about 0.02 to 0.08 per cent vanadium and less than 1 per cent carbon for use in structural applications and in large-diameter natural-gas and oil transmission pipelines. Their high yield strength (65,000 to 80,000 psi) and consequent weight saving compared with ordinary carbon steels has resulted in savings in cost and an expanding market. Low-alloy steels containing 0.15 to 2 per cent vanadium are used in large forgings, springs, wear-resistant parts and shock resistant steels for drop-hammer dies.

Vanadium forms the extremely stable carbide which contributes to the wear resistance of tool steels; vanadium contents range from 0.20 to 5.0 percent with high-speed steels generally in the higher levels. Vanadium is also used with chromium and molybdenum in high-temperature steels. Titanium-based vanadium alloys, having high temperature and strength qualities and good weldability are used in aircraft frames, engine casings and other structures.

Table 5. Compositions of vanadium ferroalloys

	Vanadium V	Carbon C	Silicon Si	Nitrogen N	Iron Fe	Chromium Cr
Standard ferrovanadium	35-85	0.5-2.0	0.5-11			
Carvan	83-86	10-13			1-3	
Solvan	25-30		0.8-5.0 max		0.3 max	
Ferovan[1]	42.6	0.75	6.5			6.4
Nitrovan	75-80	10-12		6-7		

[1]Typical analysis.

Prices

United States vanadium prices in U.S. currency published in Metals Week.

	Dec. 20 1971	Dec. 22 1972
	($)	($)
Vanadium pentoxide, per lb of V_2O_5, fob mine or mill		
98% fused	1.50(*n*)	1.50
Air dried (technical)	2.21	2.21
Dealers (mainly export)	1.50	1.50

	Dec. 20 1971	Dec. 22 1972
	($)	($)
Ferrovanadium, per lb V, packed fob shipping point, freight equalized to nearest main producer		
Standard grade	4.12	4.19
Carvan	3.48	3.66
Dealers (mainly export)	(*n*)	(*n*)
Ferovan	3.68	3.68

[n] Nominal.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900-1	Vanadium ores and concentrates	free	free	free
37520-1	Vanadium oxide	free	free	5
35101-1	Vanadium metal, ex-alloy	free	5	25
37506-1	Ferrovanadium	free	5	5

United States

Item No.		Effective on and After January 1 1970	1971	1972
		($)	($)	($)
601.60	Vanadium ores and concentrates	free	free	free
632.58	Vanadium metal, unwrought, waste and and scrap (duty on waste and scrap suspended to June 30, 1973)	7	6	5
632.68	Vanadium alloys, unwrought	10	9	7.5
633.00	Vanadium metal, wrought	12.5	10.5	9
607.70	Ferrovanadium	8.5	7	6
422.60	Vanadium pentoxide	22	19	16
422.58	Vanadium carbide	8.5	7	6
427.22	Vanadium salts	22	19	16
422.62	Other vanadium compounds	22	19	16

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Zinc

G.S. BARRY

Canadian recoverable zinc output in 1972 was 1,323,646 short tons, about 6 per cent higher than in 1971. Canada remained the world's leading mine producer accounting for 29.3 per cent of the total production of noncommunist countries. Production of refined zinc increased to 524,885 tons in 1972 from 410,643 tons in 1971. Plants operated nearly at their most efficient capacities against a background of buoyant markets.

Canadian exports of zinc in concentrates decreased by 14 per cent from 891,092 tons in 1971 to 766,202 tons in 1972, reflecting in part an increased demand for domestic processing and in part a world shortage of smelting and refining capacity.

Exports of refined zinc in 1972 were 408,310 tons, a major improvement from 312,462 tons in 1971. Exports to the United States increased by 72 per cent to 272,878 tons in 1972. This large increase was due to a sustained drop in the U.S. domestic metal production resulting from smelter closures as well as a record 14 per cent increase in consumption. Sales from the U.S. stockpile totalling 200,223 tons helped compensate for the severe shortfall of primary supplies. Britain imported 74,232 tons of zinc from Canada, 14 per cent more than in 1971, but almost all smaller importing countries recorded proportionally lower imports of Canadian metal as the U.S. shortage appeared to have top priority on supplies. Japan and Australia increased their market penetration in the Third countries at the expense of Canada.

Domestic industry

Mine production. Table 2 gives information on the operations of the 37 mining enterprises that produced zinc-bearing ores or concentrates on a regular basis during 1972 and whose content of zinc was destined for recovery. Of the mines that produced more than 20,000 tons of zinc in concentrates in 1972, seven increased production and six reported decreases as compared to 1971. For the second consecutive year some of the largest mines, the Ecstall mine at Timmins, Ontario, the Faro mine, Yukon Territory and Brunswick No. 6 and No. 12 mines posted increases. Hudson Bay Mining and Smelting Co., Limited posted a large increase, offsetting losses caused by a prolonged strike in 1971. Heath Steele Mines Limited in New Brunswick on the other hand, lost production owing to a two-month strike.

The 37 mining enterprises listed on Table 2 had a combined mill capacity of 90,550 tons per day of which the large mills (1,000 tons per day and over) accounted for 84,950 tons. Zinc production per ton of installed mill capacity was 15.7 tons. The zinc producing enterprises reported a total employment of 13,029 for 1972. The 21 large concentrators milled 25,770,000 tons, operating at 83 per cent of their theoretical annual capacity of 31,010,000 tons based on a 365-day year.

Zinc: Salient Statistics – Canada

(1000's of short tons)

	1969	1970	1971	1972	1973^e	1975/6^e
A) Mine Production	1,290	1,381	1,400	1,402	1,526	1,590
B) Production of primary zinc	466	461	411	525	619	720
C) Export of zinc in conc.	805	892	891	766	879	772
D) Export of primary zinc	307	351	312	408	490	585
E) Domestic consumption (primary zinc only)	119	106	115	123	127	133
Export processing index D/D+C	27	28	26	35	36	43

Newfoundland. Production of zinc, lead and silver at the Buchans mine was almost double that of 1971 when a 21-week strike interrupted operations. The extensive exploration program of the past several years has failed to find a new orebody, and has been curtailed. The present mine has ore reserves sufficient for six more years based on present costs and metal prices. The mine is jointly owned by American Smelting and Refining Company, the operator of Terra Nova Properties Limited, a wholly-owned subsidiary of Price (Nfld.) Pulp & Paper Limited.

Teck Corporation Limited and Amax Exploration, Inc. (⅔/⅓ respectively on a sharing basis) began exploration on a promising zinc-lead deposit at Daniel's Harbour on the western coast of the island. Several million tons of low- to medium-grade material have been outlined in the past and the companies hope to delineate higher grade sections that would permit mining. The deposit has many similarities to the Mississippi Valley type deposits of Eastern and Central Tennessee. The mineralization consists of light-coloured sphalerite in porous, brecciated dolomitized limestone.

Nova Scotia. The province's only former producer, the Walton mine operated by Dresser Minerals, Division of Dresser Industries, Inc., ceased mining in 1970 and milled stockpiled material in 1971. Throughout the province there are formations with good potential for lead-zinc mineralization. This was recognized by Imperial Oil Enterprises Ltd. which took an option for a claim group on the Cuvier Mines Ltd. property centring around the Gays River lead-zinc showings, 30 miles north of Halifax. An extensive drilling program is planned for 1973. Success in Nova Scotia could mean discovery of larger medium-grade deposits since conditions are similar to reef formations that have basic similarities to the Pine Point area of the Northwest Territories.

New Brunswick. It was a year of transition for Brunswick Mining and Smelting Corporation Limited, reorganized with the assistance of Noranda Mines Limited which controls 51.4 per cent of the company. The objective was to eliminate unprofitable ISF smelting operations by converting these facilities to a lead smelter, modernize mining and milling facilities, moderately increase ore tonnage mined and rationalize long-term mining plans based on new development schemes and re-evaluation of ore reserves. These changes were successfully carried through while substantially increasing production from 1971 levels at the No. 6 open-cast mine and No. 12 underground mine. Extensive development at the No. 12 mine was carried down to the 2,800 level; mechanized cut-and-fill stoping was extended and now accounts for 80 per cent of production. During a shut down from July 24 to August 13 to reduce concentrate inventories, new loading pockets and skips were installed in the No. 2 shaft of the No. 12 mine. The hoisting capacity at the mine was increased from 5,000 to 6,500 tons per day. The No. 12 concentrator was refitted and its capacity increased to 6,350 tons per day. Ore reserves show a significant increase in tonnage and grade compared to the previous year as a result of new ore development and the elimination of low-grade material that will not be mined owing to the more selective mechanized cut-and-fill mining method. At the end of 1972 proven and probable lead-zinc ore in the No. 12 orebody, (after allowance for dilution) totalled 73,526,000 tons averaging 9.35 per cent zinc, 3.84 per cent lead, 0.27 per cent copper and 2.78 oz. silver per ton compared with 68,145,000 tons at 12.2 per cent combined lead-zinc the previous year. No. 6 orebody had reserves of 4,323,000 tons averaging 6.09 per cent zinc, 2.25 per cent lead, 0.41 per cent copper and 2.07 oz. silver per ton at the end of 1972.

New Brunswick's second largest base metal producer, the Little River mine near Newcastle, had a poor production record in 1972 owing to a 2-month strike and a substantially lower grade of ore mined. The mine is operated by Heath Steele Mines Limited, a wholly-owned subsidiary of American Metal Climax, Inc. and The International Nickel Company of Canada, Limited. The company completed a highly successful underground exploration program that sparked expansion plans. The initial phase of the $10,700,000 program began in 1972 and is expected to be completed in 1975. It includes sinking a new 3,000-foot production shaft to maintain production after 1975 at an annual rate of 1,440,000 tons of ore. Existing milling facilities will be expanded from 3,000 to 4,000 tons per day by adding grinding and flotation equipment (existing crushing and dewatering facilities are adequate). With the completion of the expansion, the mine will produce 96,000 tons of zinc concentrates, 44,000 tons of lead concentrates and 50,000 tons of copper concentrates annually. The deposits occur in three zones, totalling 33,765,000 tons of ore averaging 4.55 per cent zinc, 1.63 per cent lead, 1.16 per cent copper and 1.76 oz. silver per ton.

Nigadoo River Mines Limited suspended its operations at Robertville in January 1972. Sullivan Mining Group Ltd. which controls 96.11 per cent of the company announced that it will resume operations if metal prices improve sufficiently. The remaining reserves are 1,248,000 tons averaging 3.22 per cent zinc, 3.23 per cent lead, 0.24 per cent copper, and 4.04 oz. silver per ton.

Anaconda Canada Limited maintained interest in its Caribou property after suspending pilot concentrating operations in 1971. Ways are being sought for bringing this very large deposit of complex copper-zinc-lead ore into production in the middle seventies.

Quebec. Mattagami Lake Mines Limited, the province's largest zinc producer operated at near capacity in 1972 but zinc output at 91,000 tons decreased by

text continued on page 497

Table 1. Canada, zinc production, trade and consumption, 1971-72

	1971		1972p	
	short tons	$	short tons	$
Production				
All forms[1]				
Ontario	365,725	122,371,696	409,970	156,370,000
Northwest Territories	224,317	75,056,384	210,000	80,094,000
New Brunswick	161,514	54,042,606	207,267	79,056,000
Quebec	174,419	58,360,594	157,552	60,090,000
British Columbia	152,726	51,101,993	133,757	51,015,000
Yukon	116,567	39,003,342	115,000	43,861,000
Manitoba	24,986	8,360,479	45,925	17,516,000
Newfoundland	20,833	6,970,621	27,600	10,527,000
Saskatchewan	8,647	2,893,451	16,575	6,322,000
Total	1,249,734	418,161,166	1,323,646	504,851,000
Mine output[2]	1,400,217		1,401,693	
Refined[3]	410,643		524,885	
Exports				
Zinc, blocks, pigs, and slabs				
United States	158,302	41,246,000	272,878	85,902,000
Britain	65,160	16,916,000	74,232	21,606,000
India	16,545	3,541,000	12,023	3,502,000
West Germany	9,402	2,358,000	4,615	1,499,000
Brazil	9,267	1,917,000	5,354	1,367,000
Taiwan	1,251	310,000	4,129	1,274,000
Italy	3,331	712,000	4,882	1,208,000
Venezuela	5,328	1,112,000	3,573	881,000
Hong Kong	3,022	771,000	2,760	876,000
Thailand	2,932	754,000	2,325	730,000
Belgium & Luxembourg	2,057	434,000	2,416	722,000
Malaysia	527	107,000	2,206	681,000
Singapore	1,627	453,000	1,530	468,000
Israel	1,979	417,000	1,900	458,000
Turkey	1,494	302,000	1,859	446,000
France	662	140,000	1,486	361,000
Other countries	29,576	6,554,000	10,142	2,779,000
Total	312,462	78,044,000	408,310	124,760,000
Zinc contained in ores and concentrates				
Belgium & Luxembourg	267,514	43,410,000	190,631	32,064,000
Japan	169,672	28,763,000	150,229	27,811,000
West Germany	62,791	9,683,000	118,897	20,034,000
United States	235,397	29,264,000	151,871	19,149,000
France	46,601	8,409,000	53,785	9,533,000
Netherlands	41,743	6,786,000	34,731	7,211,000
India	13,526	1,828,000	16,484	2,798,000
Italy	11,022	1,634,000	7,864	2,501,000
Norway	8,364	1,064,000	10,524	1,646,000
Poland	–	–	10,847	1,592,000
Britain	26,724	3,405,000	9,197	1,536,000
Other countries	7,738	1,423,000	11,142	1,836,000
Total	891,092	135,669,000	766,202	127,711,000

Table 1 (concl'd)

	1971r			1972p		
	Primary	Secondary	Total	Primary	Secondary	Total
	(short tons)			(short tons)		
Zinc and alloy scrap dross and ash (gross weight)						
United States		2,107	452,000		3,555	759,000
Netherlands		1,462	157,000		2,355	236,000
Britain		210	25,000		973	125,000
Belgium & Luxembourg		1,710	118,000		1,633	113,000
Ireland		–	–		329	87,000
South Korea		130	25,000		319	76,000
Other countries		333	56,000		729	126,000
Total		5,952	833,000		9,893	1,522,000
Zinc fabricated materials, nes						
United States		5,449	2,303,000		5,990	2,612,000
Britain		265	76,000		385	81,000
Venezuela		183	78,000		132	60,000
Netherlands		122	13,000		360	28,000
Hong Kong		12	5,000		67	24,000
Other countries		1,066	185,000		342	77,000
Total		7,097	2,660,000		7,276	2,882,000
Imports						
In ores and concentrates		82	23,000		339	84,000
Dust and granules		1,329	565,000		1,340	597,000
Slabs, blocks, pigs and anodes		4,003	1,281,000		12,497	4,410,000
Bars, rods, plates, strip and sheet		511	312,000		478	317,000
Slugs, discs, shells		5	3,000		–	–
Zinc oxide		2,370	736,000		2,658	787,000
Zinc sulphate		1,399	182,000		1,111	151,000
Zinc fabricated material, nes		578	682,000		907	1,091,000
Total		10,277	3,784,000		19,330	7,437,000
Consumption						
Zinc used for in the manufacture of:						
Copper alloys (bronze, brass, etc.)	13,746	*)		15,111	*)	
Galvanizing		)243	69,584		)493	75,176
Electro	1,595	*)		2,034	*)	
Hot-dip	53,450	*)		57,538	*)	
Zinc die-cast alloy	20,556	–	20,556	20,524	9	20,533
Other products (including rolled and ribbon zinc, zinc oxide)	25,586	4,845	30,431	28,274	4,355	32,629
Total	115,433	5,138	120,571	123,481	4,857	128,338
Consumer stocks on hand at end of year	8,634	1,028	9,662	15,251	1,450	16,701

Source: Statistics Canada.
[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Zinc content of ores and concentrates produced. [3] Refined zinc produced from domestic and imported ores.
p Preliminary; – Nil; nes Not elsewhere specified. *Not available for publication. r Revised.

Table 2. Principal zinc mines in Canada, 1972 and (1971)

Company and Location	Mill or Mine Capacity	Grade of Ore: Zinc	Lead	Copper	Silver	Ore Produced	Contained Zinc Produced	Remarks
	(tons ore/day	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Newfoundland								
American Smelting and Refining Company, Buchans Unit, Buchans	1,250 [1,250]	12.89 [12.39]	7.18 [6.90]	1.13 [1.08]	3.73 [3.71]	291,000 [173,000]	34,533 [19,366]	Company reports 6 to 7 years ore reserves remaining
New Brunswick								
Anaconda Canada Limited, New Mines Division, Bathurst	–	–	–	–	–	–	–	Trial production started Jan. 1971; operations suspended Nov. 7, 1971
Brunswick Mining and Smelting Corporation Limited, Bathurst								
No. 6 mine	3,500 [3,500]	5.46 [5.76]	2.04 [. .]	0.37 [0.36]	2.10 [. .]	1,743,610 [1,300,946]	77,708 [65,590]	One third of ore milled in No. 12 mill. No. 6 mill now produces Zn and Pb concentrates in place of bulk concentrate
No. 12 mine	6,350 [6,000]	9.10 [8.11]	3.62 [3.25]	0.27 [0.30]	2.82 [2.44]	1,513,949 [1,567,352]	112,770 [94,510]	Mill refitted to handle about 2,000 tpd from No. 6 mine
Heath Steele Mines Limited, Newcastle	3,000 [3,000]	3.93 [5.29]	1.46 [2.23]	1.13 [0.97]	1.70 [2.21]	835,867 [972,456]	25,132 [39,270]	On strike July 1 to Aug. 29, 1972. Mill expansion to start in 1973 to 4,000 tpd by 1976
Nigadoo River Mines Limited, Robertville	– [1,000]	– [2.66]	– [2.53]	– [0.27]	– [3.37]	– [322,956]	– [7,786]	Operations suspended Jan. 4, 1972
Quebec								
Delbridge Mines Limited, Noranda	– [–]	– [8.62]	– [–]	– [0.45]	– [2.86]	– [154,172]	– [11,639]	Mining stopped in Sept. 1971
Falconbridge Copper Limited, Lake Dufault Division, Noranda	1,500 [1,500]	4.39 [2.02]	– [–]	3.16 [1.48]	1.40 [0.60]	561,625 [506,095]	19,109 [7,285]	Full year production at the new Millenbach mine. Norbec's lower grade ore supplies approx. 400 tpd to mill
Joutel Copper Mines Limited, Joutel	700 [–]	12.16 [–]	– [–]	. . [–]	. . [–]	70,232 [–]	6.761 [–]	Began production of zinc from separate orebody in August 1972. Reserves at December 31, 1972 at 144,600 tons of 11.18% zinc.

Table 2. Principal zinc mines in Canada, 1972 and (1971) (cont'd)

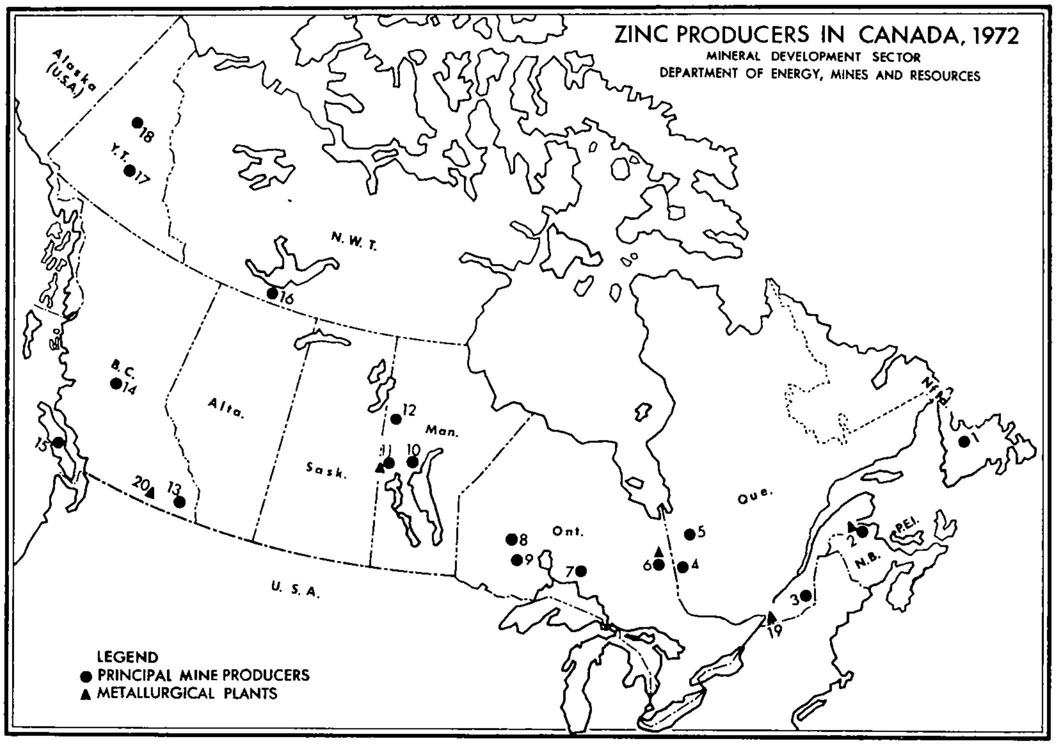
Company and Location	Mill or Mine Capacity	Grade of Ore Zinc	Lead	Copper	Silver	Ore Produced	Contained Zinc Produced	Remarks
	(tons ore/day	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Kerr Addison Mines Limited, Normetal (Normetal Mine)	1,000 [1,600]	5.29 [1.96]	– [–]	1.73 [1.76]	1.43 [1.50]	326,475 [335,298]	14,695 [16,398]	Salvage basis. Mine is expected to cease operations by early 1974
Manitou-Barvue Mines Limited, Val-d'Or	1,600 [1,600]	1.16 [1.96]	0.33 [1.42]	. . [. .]	4.68 [4.42]	60,234 [225,915]	500 [3,568]	Operations suspended October 1971 to July 1972 due to low metal prices. Plan to increase production in 1973. Custom-milled the Louvem ore (227,712 tons)
Mattagami Lake Mines Limited, Mattagami	3,850 [3,850]	7.4 [9.3]	– [–]	0.56 [0.62]	0.88 [1.07]	1,370,167 [1,386,167]	90,889 [118,007]	
Orchan Mines Limited, Matagami Orchan Mine	1,900 [1,900]	10.6 [10.66]	0.20 [. .]	1.05 [0.93]	1.1 [1.27]	376,840 [409,492]	36,199 [39,736]	From beginning of 1973, ore will be sent to Orchan Mine
Quemont Mines Limited, Noranda	[2,400]	[2.06]	[–]	[0.78]	– [1.03]	– [332,206]	– [4,948]	Milling and mining operations ceased on Nov. 11, 1971
Sullivan Mining Group Ltd., Stratford Centre, Cupra Mine	1,500 [1,400]	3.97 [3.86]	0.60 [0.63]	2.24 [2.29]	0.99 [1.05]	117,339 [134,663]	4.380 [4,066]	One reserves at August 1972 at Cupra and D'Estrie totalled 1,450,080 tons of 2.20% zinc, 0.62% lead, 2.99% copper and 1.05 oz. silver a ton
D'Estrie Mine	– [–]	3.28 [2.52]	0.72 [0.57]	2.70 [2.11]	1.21 [0.97]	109,138 [83,506]	3,367 [1,649]	Ore milled at Cupra mill
Weedon Mine	– [–]	0.76 [0.85]	– [–]	1.82 [1.44]	0.35 [0.32]	177,248 [181,037]	1.072 [869]	Ore milled at Cupra mill
Ontario								
Big Nama Creek Mines Limited, Manitouwadge	– [–]	– [5.12]	– [0.06]	– [0.81]	– [1.07]	– [41,717]	– [. .]	Mine closed in Sept. 1971
Canadian Jamieson Mines Limited, Timmins	– [550]	– [2.14]	– [–]	– [1.33]	– [. .]	– [20,567]	– [297]	Mine closed Feb. 12, 1971

Ecstall Mining Limited, Timmins	10,000 [10,000]	10.14 [9.74]	0.39 [.35]	1.44 [1.38]	4.35 [4.05]	3,628,501 [3,673,350]	330,009 [317,520]	Preproduction development work substantially completed on 800 and 1,200 levels. Underground mine expected to supply 2,000 tpd to concentrate by end of 1973.
Jameland Mines Limited, Timmins	– [–]	3.59 [1.95]	– [–]	0.94 [1.29]	. . [. .]	138,029 [156,586]	2.831 [1.661]	Ore treated at Kam-Kotia mill. Mine closed Dec. 20, 1972
Kam-Kotia Mines Limited, Timmins	2,500 [2,500]	2.38 [2.51]	– [–]	0.73 [0.78]	. . [. .]	422,399 [480,145]	5,888 [8,076]	Operations terminated Dec. 30, 1972
Mattabi Mines Limited, Sturgeon Lake	3,000 [–]	11.97 [–]	1.27 [–]	1.27 [–]	4.99 [–]	438,838 [–]	44,316 [–]	Production commenced in July 1972
Noranda Mines Limited, Geco Division, Manitouwadge	5,200 [5,000]	4.30 [5.52]	0.15 [. .]	2.12 [2.27]	1.93 [2.03]	1,815,164 [1,759,952]	61,555 [80,000]	Facilities to decant and recycle tailings – pond water installed in 1972
Selco Mining Corporation Limited South Bay Division, Uchi Lake	500 [500]	12.0 [13.29]	. . [–]	2.1 [2.33]	3.2 [. .]	183,000 [130,019]	22,734 [14,844]	Ramp from 300 to 600 level completed ahead of schedule. Commenced mining below 300 level.
Willroy Mines Limited (incl. Willecho mine), Manitouwadge	1,700 [1,600]	3.27 [3.33]	0.14 [0.13]	1.10 [0.89]	1.41 [1.36]	431,067 [427,589]	10,988 [11,707]	Extensive exploration program scheduled for 1973
Manitoba and Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake (Flin Flon, Schist Lake, Flexar, Chisel Lake, Stall Lake, Osborne Lake, Anderson Lake, Dickstone, White Lake, Ghost Lake)	6,800 [7,500]	3.28 [3.2]	. . [0.2]	2.67 [2.8]	0.59 [0.5]	1,847,903 [1.084,000]	53,000 [29,648]	Flexar Mine closed in 1972; White Lake and Ghost Lake mines started production. Central mill at Flin Flon treats ore from all mines.
Sherritt Gordon Mines Limited, Lynn Lake, Fox mine	3,000 [3,000]	1.40 [1.54]	– [–]	2.14 [2.86]	. . [. .]	946,000 1,022,000]	5.449 [5,659]	
British Columbia								
Bradina Joint Venture, Owen Lake	600 [–]	4.45 [–]	0.89 [–]	0.42 [–]	5.31 [–]	111,024 [–]	3,981 [–]	Mill commenced operation in March 1972
Cominco Ltd., Sullivan mine, Kimberley	10,000 [10,000]	10.8[1] [11.3][1]		. . [. .]	. . [. .]	1,925,099 [2,005,301]	100,680 [102,015]	In late 1972, company reopened the H.B. mine which started production early in 1973

Table 2. Principal zinc mines in Canada, 1972 and (1971) (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Zinc	Lead	Copper	Silver	Ore Produced	Contained Zinc Produced	Remarks
	(tons ore/day	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Kam-Kotia-Burkam Joint Venture, Silmonac mine, Sandon	150 [150]	6.62 [6.60]	5.81 [6.39]	– [–]	16.44 [17.99]	27,429 [39,154]	1,693 [2,438]	
Reeves MacDonald Mines Limited, Remac Annex mine	1,000 [1,000]	7.07 [8.63]	0.59 [0.89]	– [–]	1.91 [2.51]	180,188 [166,089]	11,846 [13,540]	Ore milled at Reeves mill. Operation suspended July 1971 at Reeves mine because of ore depletion. Developing new ore zone under Pend-d'Oreille River.
Teck Corporation Limited, Beaverdell mine	115 [115]	0.76 [0.80]	0.72 [0.70]	0.003 [–]	18.23 [17.52]	37,091 [36,404]	284 [290]	Exploration and development continue to locate new ore.
Western Mines Limited, Buttle Lake, V.I.	1,100 [1,000)	6.02 [6.9]	0.68 [0.7]	1.85 [2.0]	.. [1.6]	374,022 [386,541]	20,786 [22,901]	New additions to concentrator in 1972 to mill Myra Falls mine high grade silver ore. Tunnel being driven through Myro Mountain to explore extension of ore zone.
Yukon Territory								
Anvil Mining Corporation Limited, Faro	8,000 [7,700]	6.22 [6.74]	4.63 [4.92]	– [–]	.. [..]	2,905,530 [2,673,000]	140,523 [136,419]	Expanding mill capacity to 10,000 tpd; no increase in concentrate production planned.
United Keno Hill Mines Limited, Elsa	550 [550]	3.19 [5.19]	4.61 [5.17]	– [–]	34.23 [30,57]	80,646 [94,754]	1,738 [3,759]r	Installed new hydraulic backfill plant for cut and fill stopes
Northwest Territories								
Pine Point Mines Limited, Pine Point	10,000 [10,000]	6.2 [6.5]	2.7 [2.6]	– [–]	.. [..]	3,809,729 [3,891,927]	220,045 [239,369]	Improvements to flotation to reduce MgO content in conc. in progress in 1972 and 1973. Company purchased property of Coronet Mines Ltd.

– Nil; . . Not available; r Revised.
[1]Combined lead-zinc.



Principal Producers
(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
3. Sullivan Mining Group Ltd.
4. Falconbridge Copper Limited, Lake Dufault Division
   Manitou-Barvue Mines Limited
   Kerr Addison Mines Limited (Normetal mine)
5. Mattagami Lake Mines Limited
   Orchan Mines Limited
6. Ecstall Mining Limited
   Kam-Kotia Mines Limited
7. Noranda Mines Limited (Geco mine)
   Willroy Mines Limited
8. Selco Mining Corporation Limited
9. Mattabi Mines Limited
10. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Dickstone, Ghost Lake, Anderson Lake)
11. Hudson Bay Mining and Smelting Co., Limited (Flin Flon, Schist Lake)
12. Sherritt Gordon Mines, Limited (Fox Lake mine)
13. Cominco Ltd. (Sullivan mine)
    Teck Corporation Limited (Beaverdell mine)
    Reeves MacDonald Mines Limited (Annex mine)
    Kam-Kotia-Burkam Joint Venture (Silmonac mine)
14. Bradina Joint Venture
15. Western Mines Limited
16. Pine Point Mines Limited
17. Anvil Mining Corporation Limited
18. United Keno Hill Mines Limited

Metallurgical Plants

19. Canadian Electrolytic Zinc Limited, Valleyfield
11. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
20. Cominco Ltd., Trail
6. Ecstall Mining Limited

Table 3. Prospective zinc-producing mines

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Grade of Ore: Zinc	Grade of Ore: Lead	Grade of Ore: Copper	Grade of Ore: Silver	Remarks
		(tons ore /day)	(tons)	(%)	(%)	(%)	(%)	
New Brunswick								
Nigadoo River Mines Limited, Robertville	1974	1,000	1,248,000	3.22	3.23	0.24	4.04	Company will dewater shaft in 1973 and consider re-opening the mine in 1974.
Quebec								
Orchan Mines Limited Garon Lake mine	1973	400	395,000	3.4	–	1.7	..	Decline sunk to 500 ft. level. Regular production commenced January 1973. Ore trucked to Orchan mill.
Orchan Mines Limited Norita Division	1975	..	1,637,000	7.6	–	0.7	1.0	Optioned from Noranda. Shaft, decline and plant installation to commence in mid-1973. Orebody extends to depth of 1,400 feet.
Manitoba								
Hudson Bay Mining and Smelting Co., Limited, Snow Lake area, Centennial mine	1974	..	1,400,000	2.6	–	2.06	..	Reserves are to 1,200-foot level; orebody open at depth.
Sherritt Gordon Mines, Limited, Ruttan mine, Lynn Lake district	1973	10,000	51,000,000	1.61	–	1.47	..	Open-pit operation. Development on schedule.
Northwest Territories								
Coronet Mines Ltd., Pine Point	1973	..	1,372,735	10.2 (Pb+Zn)	–	–	..	Orebody purchased by Pine Point Mines Limited for $975,000.

.. Not available; – Nil

Table 4. Indicated zinc deposits under exploration

Company and Location	Indicated Ore Tonnage	Grade of Ore Zinc	Lead	Copper	Silver	Remarks
	(tons)	(%)	(%)	(%)	(oz/ton)	
Newfoundland						
Newfoundland Zinc Mines Limited, Daniel's Harbour	5,400,000	7.70	. .	. .	. .	Exploration completed in 1970-72. Reserves include 3,700,000 tons of 8.5 per cent zinc.
New Brunswick						
Anaconda Canada Limited, Bathurst, Caribou property	50,000,000	4.43	1.7	0.47	. .	In temporary production January to November 1971. Feasibility studies continue on bringing this property into production.
Chester Mines Limited, Newcastle	1,600,000	2.12	0.82	0.63	. .	Ore available for open-pit mining.
	3,300,000	. .	–	0.82	–	
	13,000,000	. .	–	0.77	. .	Ore available for underground mining. Feasibility study completed in 1970.
Key Anacon Mines Limited, Bathurst	1,950,000	5.87	2.18	0.24	2.31	Mine partly developed. Revaluation of property in 1970 led to decision to defer placing the property into production at that time.
Teck Corporation Limited, Portage Lakes area, Restigouche property	3,270,000	5.9	4.6	. .	2.50	Partly recoverable by open pit.
Quebec						
Orchan Mines Limited, Radiore No. 2	110,000	1.5[e]	–	2.5[e]	. .	Mining in prospect after 1976 upon depletion of reserves at the Garon mine.
Ontario						
Sturgeon Lake Mines Limited, Sturgeon Lake	1,928,000	7.85	–	3.0	4.54	Optioned to Falconbridge Copper Limited. Open-pit operation anticipated.
Manitoba						
Stall Lake Mines Limited, Snow Lake	672,000	2.28	. .	5.38	. .	Falconbridge Nickel Mines Limited is joint owner of this property. Exploration completed in 1971. Feasibility study on production completed. Decision deferred.

Table 4 (concl'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore Zinc	Lead	Copper	Silver	Remarks
	(tons)	(%)	(%)	(%)	(oz/ton)	
Saskatchewan						
Bison Petroleum & Minerals Limited, Brabant Lake	4,330,000	4.43	. .	0.64	. .	Further exploration planned.
Yukon Territory						
Hudson Bay Mining and Smelting Co., Limited, Tom deposit MacMillan Pass	8,645,000	8.4	8.1	–	2.75	Underground work through adit including diamond drilling in 1970–1972. Further development planned.
Kerr Addison Mines Limited, Swin Lake deposit, Vangorda Creek	5,000,000	9.5 (Pb+Zn)		. .	1.50	
Vangorda Mines Limited, Vangorda Creek	9,400,000	4.96	3.18	0.27	1.76	Feasibility study made. No further exploration.
Northwest Territories						
Arvik Mines Ltd., Little Cornwallis Island	25,000,000 plus	20.0 (Pb+Zn)		–	. .	Cominco Ltd. has a 75 per cent interest. The company states that "geological evidence suggests occurrence of a deposit of major size".
Buffalo River Exploration Limited, Pine Point	1,350,000	9.6	3.4	–	. .	Feasibility study for joint production with Coronet Mines Ltd. completed in 1971. Decision was made not to put the property into production at present.
Texas Gulf, Inc., Strathcona Sound	7,000,000	16.0 (Pb+Zn)		–	1.50	Underground exploration completed in 1970. Further work performed in 1972. Some increase in reserves possible.

. . Not available; – Nil.

some 25 per cent from the average level of some 120,000 tons achieved for the past 5 years. The company reports that lower recoveries (88.6 per cent for zinc) resulted from encountering some oxidized backfill in mining pillars as well as more than normal amounts of talc in the ore. Pillar ore made up 31.8 per cent of the total ore mined during the year. Ore reserves at the end of the year stood at 14,661,927 tons averaging 8.9 per cent zinc, 0.67 per cent copper, and 1.08 oz. silver per ton.

The Lake Dufault Division of Falconbridge Copper Limited (controlled by Falconbridge Nickel Mines Limited, 50.2 per cent) reported a substantial production increase to 19,109 tons of zinc for 1972 following a full-year production from their deep, new Millenbach mine. The Millenbach mine started production in November 1971 at 1,100 tons per day with ore treated in the Norbec concentrator; the balance of the feed, approximately 400 tons per day is from the low-grade Norbec mine. At the end of 1972 ore reserves were reported at 420,000 tons (1.66 per cent zinc, 1.13 per cent copper and 0.26 oz. silver per ton) for the Norbec mine, and 2,415,000 tons (4.35 per cent zinc, 3.45 per cent copper and 1.32 oz. silver per ton), for the Millenbach mine.

The Normetal mine of Kerr Addison Mines Limited continued operations on a salvage basis to produce 14,695 tons of zinc in 1972. The mine is expected to close in November 1973.

Orchan Mines Limited continued milling throughout 1972 at a reduced 5-days-per-week basis producing 36,199 tons of zinc or 10 per cent less than in 1971. At the end of 1972 the mine had reserves of 1,897,000 tons averaging 9 per cent zinc, 1.2 per cent copper and 0.93 oz. silver per ton. Towards the end of the year production started from the new Garon Lake mine, eight miles northeast of the main property. This small deposit will be mined for 3 to 4 years at a rate of 12,000 tons per month, and the ore will be treated in the Orchan 900/tpd-capacity custom circuit. Plans are to develop the Norita orebody (Norita Quebec Mines Limited–Noranda option) for full production by 1975 and truck the ore to the Orchan concentrator. Noranda's drilling on the Norita property indicated reserves of 1,637,000 tons averaging 7.6 per cent zinc, 0.7 per cent copper and 1.0 oz. silver per ton.

Table 5. Canada mine output, zinc, 1971-72

	1971	1972[p]
	(short tons)	
Newfoundland	17,715	32,983
Nova Scotia	33	–
New Brunswick	207,278	196,566
Quebec	207,057	168,833
Ontario	419,495	470,914
Manitoba–Saskatchewan	29,690	53,122
British Columbia	148,368	132,342
Yukon Territory	131,213	134,594
Northwest Territories	239,368	220,036
Total	1,400,217	1,401,693

Source: Statistics Canada; [p]Preliminary.

Table 6. Canada zinc production, exports and consumption, 1963-72

	Production		Exports			Consumption[3]
	All Forms[1]	Refined[2]	In ores and concentrates	Refined	Total	
	(st)	(st)	(st)	(st)	(st)	(st)
1963	473,722	284,021	213,044	200,002	413,046	73,653
1964	684,513	337,734	403,102	238,076	641,178	88,494
1965	822,035	358,498	487,445	264,200	751,645	93,796
1966	964,106	382,605	591,322	256,153	847,475	107,052
1967	1,111,453	405,136	735,705	297,652	1,033,357	107,779
1968	1,159,392	426,728	855,818	318,707	1,174,525	115,978
1969	1,207,625	466,357	804,665	307,394	1,112,059	118,681
1970	1,251,911	455,471[r]	892,043	351,454	1,243,497	105,641
1971	1,249,734	410,643	891,092	312,462	1,203,554	111,341
1972[p]	1,323,646	524,885	766,202	408,310	1,174,512	137,699[4]

Source: Statistics Canada.
[1]New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2]Refined zinc produced from domestic and imported ores. [3]Refined primary zinc only, reported by consumers. [4]Producers' domestic shipments of refined metal.
[p]Preliminary; [r]Revised.

Manitou-Barvue Mines Limited suspended operations at their Val-d'Or mine in October 1971, and resumed production in July 1972 at a reduced rate of 10,000 tons per month. It is planned to increase production of the zinc-silver ore to 20,000 tons per month in May 1973. Reserves are 1,016,472 tons with an average grade of 2.93 per cent zinc, 0.36 per cent lead and 4.57 oz. silver per ton.

Joutel Copper Mines Limited began mining their small separate zinc orebody in August 1972. At the end of the year reserves were at 144,600 tons grading 11.18 per cent zinc. The mine expects to close near the end of 1973.

Exploration activity in the province resulted in the discovery of significant copper-zinc mineralization in the Troilus Lake area, about 70 miles north of Chibougamau, by Selco Mining Corporation Limited (optioned from Muscocho Explorations Limited) and in Hebecourt Township 70 miles northwest of Noranda by the Iso-Copperfields group. In both cases indications are that small- to medium-size deposits might be present.

Ontario. Ecstall Mining Limited is a wholly-owned subsidiary of Texas Gulf Inc. The company operates the largest zinc mine in Canada, the Kidd Creek mine near Timmins. During 1972 record production was achieved from the open-pit operations while initial output from the underground operations commenced in December. The current underground stoping provides about 2,000 tons a day to the concentrator and will be expanded over the next few years until it will supply the entire mill feed of 10,000 tons per day by 1976-77. The open pit is starting its twelfth 40-foot bench and will reach its final nineteenth bench at a depth of 760 feet by 1977. In mining and concentrating there are two separate systems to handle ore from the zinc-lead-silver and the copper-rich parts of the mine. The concentrator has three separate circuits; one for each of the two types and one that can easily be adapted to handle either. Currently the output is 6,500/tpd of the copper-rich ore and 3,500/tpd of the zinc-lead-silver ore. During the transition from open-pit to underground mining the ratio of copper-rich ore will decrease so that by 1975 slightly more zinc ore than copper ore will be produced. After complete conversion, however, by 1977 the underground mine will continue to supply copper-rich ore to zinc-lead-silver ore at an average ratio of 2 to 1. At year-end reserves were conservatively estimated at 84,000,000 tons.

Noranda Mines Limited recorded a substantial drop in production at its Geco Division, Manitouwadge mine due to a two-month strike that ended in June. The company reported a small drop in reserves to 29,500,000 tons averaging 4.37 per cent zinc, 1.97 per cent copper and 1.82 oz. silver per ton. The second Manitouwadge producer, Willroy Mines Limited, continued production at normal levels. The company plans an extensive exploration program to increase reserves currently stated to be sufficient only for two more years of operation.

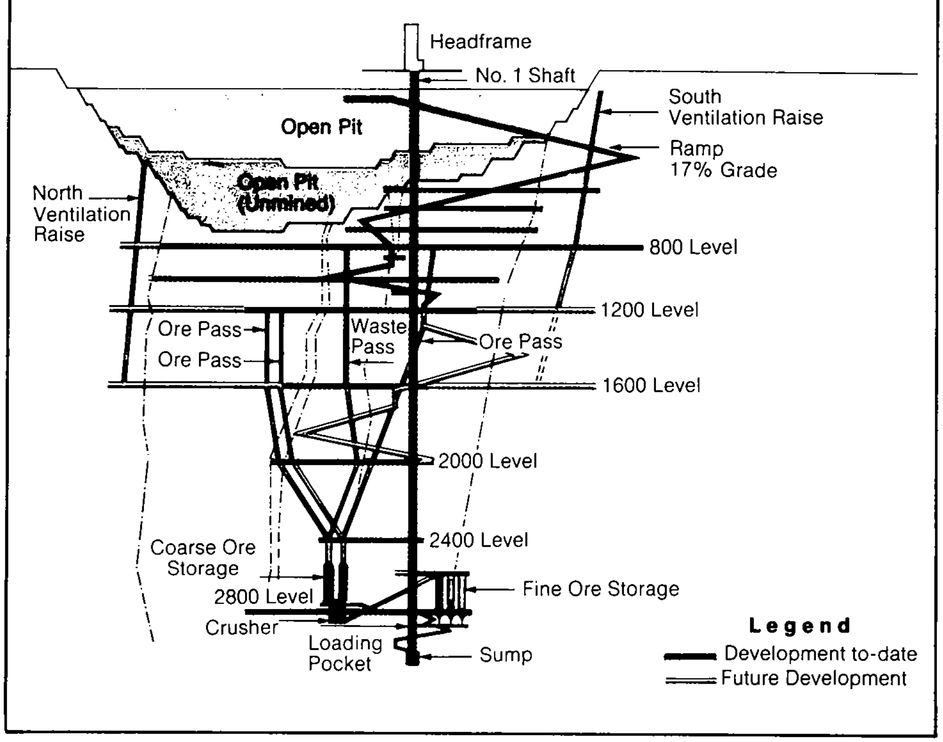
Mattabi Mines Limited celebrated the inauguration of its mine in the Sturgeon Lake area in August 1972. The mine commenced production in July and achieved full capacity operations by the end of the year. It will produce at an annual rate of 90,000 tons of zinc. The mine starts with an initial life expectancy of about 12 years with reserves of 12.9 million tons averaging 7.6 per cent zinc, 0.91 per cent copper, 0.84 per cent lead and 3.13 oz. silver per ton. Two thirds will be mined by open-pit methods. The property was put into operation in record time of less than one year at a cost of $40.1 million. The concentrator was designed for a capacity of 3,000/tpd. Total employment in mining and milling operations will vary between 250 and 300. It is expected the district will have other producers in the near future, with three additional deposits already discovered and amenable to exploitation. Falconbridge Copper Limited (jointly with NBU Mines Limited) holds a deposit of 1.9 million tons averaging 7.85 per cent zinc, 3.0 per cent copper and 4.54 oz. silver per ton. This deposit extends into the adjacent ground of Mattagami Lake Mines Limited that was purchased by Falconbridge to enable mining the orebody as a single entity. The latter company still holds two smaller orebodies in the same area: the Lyon Lake ore zone of 1,097,275 tons averaging 6.81 per cent zinc, 1.03 per cent copper, 0.59 per cent lead and 2.96 oz. silver per ton and the Creek zone of 908,000 tons averaging 8.84 per cent zinc, 1.66 per cent copper, 0.76 per cent lead and 4.71 oz. silver per ton.

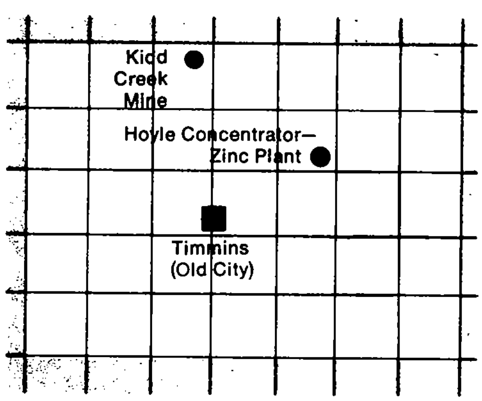
Selco Mining Corporation Limited, completed a record year, producing 22,734 tons of zinc at their South Bay mine in western Ontario. The company reports proven reserves of 520,719 tons grading just over 2 per cent copper, 14 per cent zinc and over 3 ounces silver per ton, sufficient for about four years of operation. Two Timmins producers terminated mining in December 1972, Jameland Mines Limited and Kam-Kotia Mines Limited. Ore reserves were exhausted at both properties.

Lynx-Canada Explorations Limited plans to open a small mine at Long Lake in the Rideau Lakes area. The company has reserves of about 90,000 tons grading in excess of 20 per cent zinc, enough for $1^1/_2$ to 2 years of operations. Portable beneficiating facilities using a sink-float gravity concentrating method are planned.

Manitoba. Hudson Bay Mining and Smelting Co., Limited continued full production from 9 mines in the Flin Flon and Snow Lake districts of Manitoba and Saskatchewan. The company closed the Flexar mine owing to ore exhaustion and opened the White Lake and Ghost Lake mines. Development of the Centennial mine, a copper-zinc orebody will start in 1973. The

Side view of Kidd Creek Mine





The Kidd Creek mine and the concentrator-zinc plant, some 17.5 miles apart, are all now in the new City of Timmins. The new city, incorporated January 1, 1973, covers over 1260 square miles, making it one of the largest in the world. It has a population of some 42,000 people.

This longitudinal projection is a side view of the Kidd Creek Mine looking from west to east, with the headframe and shaft in the foreground and the open pit beyond.

orebody contains approximately 1.4 million tons of 2.6 per cent zinc and 2.06 per cent copper to the 1,200-foot level and is still open at depth.

Sherritt Gordon Mines, Limited had to reduce production at its Fox Lake mine largely because of difficulties in mining the first underground pillar. Copper output however was more affected than zinc. The company continued to experience poor recoveries in the zinc circuit of the concentrator and the grade of the concentrate has been unsatisfactory. An acid circuit has been installed to improve recovery. Good progress was made at the Ruttan copper-zinc mine towards a start-up of the 10,000/tpd concentrator in April-May 1973. Reserves total 51 million tons averaging 1.61 per cent zinc and 1.47 per cent copper to 2,000 feet, and the zone is open to depth. Open-pit reserves including dilution are 21,015,660 tons of 2.12 per cent zinc and 1.34 per cent copper to the 720-foot bottom level. After six years of open-pit mining it is planned to phase in the underground operation, so that by the eighth year of operation, full production from underground will be at a rate of 2,500,000 per year. Mining method will be sub-level stoping with access by a decline. Ruttan's production of zinc concentrates has been contracted for export to Japan for a 10-year period.

Saskatchewan. Exploration for zinc in 1972 resulted in the discovery of additional low-grade mineralization in the George Lake area that might give a new dimension to the potential of that province. A deposit of about 5 million tons grading about 3 per cent zinc and 1 per cent lead had been outlined previously.

British Columbia. Cominco Ltd.'s Sullivan mine at Kimberley produced at close to 1971 levels despite a 3-week strike in July that temporarily curtailed production. The company is increasing its mining rate at Sullivan to about 2.2 million tons in 1973, and re-opening the H.B. mine at Salmo in January 1973. A record production of zinc concentrate is expected in line with excellent forecast market conditions. The mine however will continue to operate at an optimum 5-day week basis. The Sullivan orebody has been in production for 64 years and ore reserves of 60 million tons are enough for another 30 years of operations. Exploration in the district is continuing. The H.B. mine went into operation in 1955 and was closed in 1966 due to depressed zinc markets; it will operate at 1,000 tons per day and reach capacity by the end of March 1973.

Reeves MacDonald Mines Limited continued production at its Annex mine (after closing its Reeves mine in July 1971) trucking its output to the Reeves' concentrator across the Pend-d'Oreille River. In 1972 the company discovered a new ore zone under the river ("East Annex") and is developing this deposit for production; it might permit the mine to operate beyond 1973 when Annex reserves will be depleted. The company stated that this zone has a potential of 600,000 tons of ore.

Western Mines Limited's production of 374,022 tons in 1972 came mainly from the Lynx mine (98.7 per cent) half from the open pit and half from the underground mine. The remainder represents initial production from the new Myra Falls underground mine. Ore reserves at the Lynx were reported at 1,114,400 tons averaging 7.3 per cent zinc, 0.9 per cent lead, 1.4 per cent copper and 2.2 oz. silver per ton. The Myra Falls reserves are 527,000 tons of 8.8 per cent zinc, 1.7 per cent lead, 0.9 per cent copper and 5.8 oz. silver per ton. The Myra deposit however includes 104,800 tons of high-grade silver-zinc ore (13.0 per cent zinc, 4.1 per cent lead, 0.9 per cent copper and 23.7 oz. silver per ton) which will be mined over the next three years. The Myra Falls mine continues to have the best potential for new ore development and a tunnel is being driven through the Myra Mountain to explore extensions of the ore zone.

In the Robb Lake area of northern British Columbia, Barrier Reef Resources Ltd. and other companies are exploring lenticular occurrences of stratiform lead-zinc mineralization occurring in conditions similar to the Pine Point deposits. The mineralization is widespread and values of 5 to 10 per cent combined lead-zinc over "mineable width" are not uncommon but lenses outlined to date are not large enough for mining.

Yukon Territory. Anvil Mining Corporation Limited showed consistent improvement in its operations in 1972. Both metal recoveries and concentrate grades improved over 1971 levels. Zinc concentrate output was 213,344 tons grading 50.67 per cent compared with 219,782 tons grading 49.83 per cent; in addition the company produced 88,007 tons of bulk concentrate grading 28.17 per cent zinc and 18.67 per cent lead which is shipped to Germany. Regular zinc concentrates are shipped to Japanese smelters. Early in 1973 an expenditure of $5 million was approved to increase mill capacity to 10,000 tons per day for the purpose of treating lower grade ore while maintaining current levels of metal concentrate output. The expanded facilities should be in operation in early 1974. Ore reserves at the end of 1972 were 55,498,000 tons grading 5.62 per cent zinc, 3.24 per cent lead and approximately 1 oz. silver per ton.

United Keno Hill Mines Limited produced zinc concentrates from their high-grade silver, Elsa, Husky and No Cash mines. Ore drawn in 1972 and remaining reserves have a much lower zinc content at about 2.5 per cent zinc against former levels of 4.5 to 6.0 per cent which accounts for the sharp drop in zinc production.

Hudson Bay Mining and Smelting Co., Limited maintained active interest in their Tom deposit near the MacMillan Pass at the boundary of the Yukon and Northwest Territories. This deposit represents a significant reserve for the future and contains 8,645,000 tons grading 8.4 per cent zinc, 8.1 per cent lead and 2.75 oz. silver per ton. The silver values in this deposit appear to increase substantially with depth. Some 45 miles south-southeast of the Tom deposit, Placer Development Limited made an important discovery in July 1972. Trenching has exposed widths of significant mineralization up to 150 feet wide containing bands ranging from 10 to 30 per cent combined lead-zinc separated by lower values. The favourable stratiform host rocks extend for a distance of at least 20 miles in the immediate vicinity of the discovery. Extensive exploration and drilling is planned for 1973.

Northwest Territories. Pine Point Mines Limited recorded slightly lower production of zinc concentrates of 391,000 tons against 416,000 tons in 1971 mainly due to the lower grade of ore treated. The Cominco strike affected shipments and produced abnormally high inventories which will be used in 1973. Additional flotation equipment was installed to reduce the magnesium oxide content in zinc concentrates and a further installation to provide an acid leach will be implemented in 1973 to meet customer limits of this contaminant. Ore reserves at the end of 1972 were 40.9 million tons averaging 6.0 per cent zinc and 2.4 per cent lead. Preparations were made at the M-40 underground zone for test mining, which include the utilization of a continuous-mining machine, to provide a guide as to the most effective method to mine lower grade flat-lying beds at depths of 120 to 150 feet. The company reports that some 22 million tons of mineralization that is not mineable under present conditions have been outlined during the past three years of exploration. Pine Point purchased for $975,000 from Coronet Mines Ltd. its two known orebodies, containing over one million tons of ore, that will be mined over the next three years. About 75 per cent of Pine Point concentrates are processed in Canada, chiefly by Cominco and the rest in USA, Japan, Europe and India.

Cominco completed its fourth season of exploration on the Hackett River property optioned from Bathurst Norsemines Ltd. The company outlined seven potential zones of base metal-silver mineralization of which two appear to have major tonnage potential. Representative grades are 6 to 10 per cent zinc, 2 to 5 per cent lead, 5 to 10 oz. silver per ton and values in copper over widths in excess of several tens of feet. Further work is planned for 1973 and possibly future years since the option expires in 1975 and many favourable anomalies remain to be explored in this highly favourable but almost inaccessible region. A major deposit in the Bathurst Inlet area may merit future construction of an overland access route from Yellowknife, especially since there is another copper deposit in the area (Kenarctic) and halfway, near Contwayto Lake, Inco holds an important gold deposit.

One of the richest deposits in Canada on Little Cornwallis Island, the Polaris property is held by Arvik Mines Ltd. (Cominco Ltd. 75% – Bankeno Mines Limited 25%). It contains in excess of 20 million tons grading over 20 per cent combined lead-zinc. Grade and tonnage indications justify confidence that a viable operation will be established once the logistics of operating in the high Arctic are worked out. Currently the greatest obstacle is the very short shipping season that averages about 35 days a year and under adverse conditions could be much shorter. The deposit is on the coast and a suitable harbour site is available nearby.

The other potential Arctic deposit is near Strathcona Sound in the northern part of Baffin Island. It is now being explored by Mineral Resources International Limited which took over the deposit from Texas Gulf, Inc. Texas Gulf retains an interest in the property. The property has a potential of some 7 million tons or more of material grading about 16 per cent combined lead-zinc. Further work in 1973, and a feasibility study to justify a 1,500 to 2,000 tons per day operation, are planned.

Metal production. Production of refined zinc at the four Canadian plants in 1972 was 524,885 tons or 28 per cent higher than in 1971. The production was distributed as follows:

	Production Refined Zinc*	Rated Annual Capacity
Canadian Electrolytic Zinc Limited, Valleyfield, Quebec	145,000	145,000
Cominco Ltd., Trail, B.C.	243,000	295,000
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Manitoba	77,023	79,000
Ecstall Mining Limited, Hoyle, Ontario	60,100	120,000

*From company annual reports.

Production of refined zinc in 1972 was at 88 per cent of rated capacity compared with 77 per cent in 1971 and 86 per cent in 1970 (Ecstall's production in 1972 was pro-rated on an eight-month basis). Canadian Electrolytic Zinc Limited treated concentrates from Quebec (Mattagami Lake Mines Limited and Orchan Mines Limited) and from Ontario (Noranda Mines Limited's Geco mine). The plant will be modified and enlarged by over 50 per cent at a cost of about $30 million. Following completion in 1975 capacity will be some 225,000 tons of zinc metal. Noranda will provide 50 per cent of the capital required for expansion and will increase its ownership of the plant to 22.67 per cent from 9 per cent currently. The balance of the plant will be owned by Mattagami Lake (51.67 per cent), Orchan (15.83 per cent) and Kerr Addison Mines Limited (9.83 per cent).

At the Belledune operations of Brunswick Mining and Smelting, construction to convert the zinc-lead ISF smelter to a lead smelter progressed throughout 1972, reducing operating time to less than 9 months. In January of 1972 the last batch of zinc was produced, amounting to 1,870 tons of ISF metal and 860 tons of S.H.G. zinc.

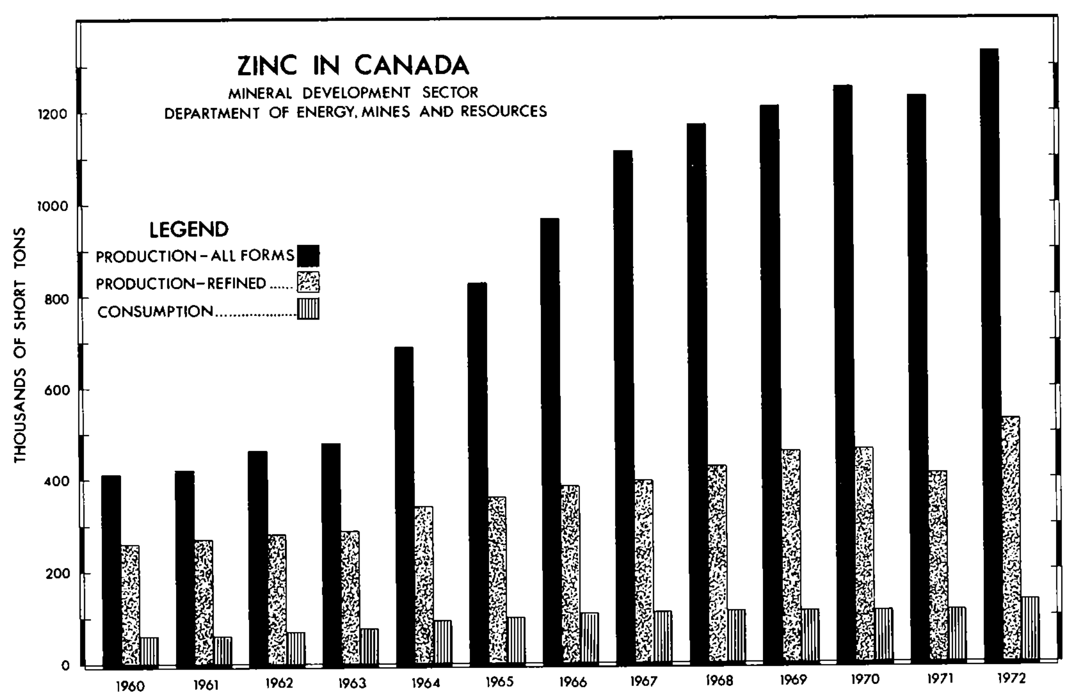
Table 7. Canada, producers' domestic shipments of refined zinc, 1971-72

	1970	1971	1972
		(short tons)	
1st Quarter	29,470	27,561	38,336
2nd Quarter	33,072	32,258	41,925
3rd Quarter	25,399	29,927	26,212
4th Quarter	29,291	32,418	31,226
Total	117,291	122,164	137,699

Source: Statistics Canada.

Hudson Bay Mining and Smelting had a record zinc metal production after a low year in 1971. The company is increasing its environmental protection program and will spend $6 million over the next two years to improve air quality in the smelter work area as well as in the community by construction of an 825-foot stack to disperse sulphur dioxide.

Ecstall's (Texas Gulf, Inc.) new zinc plant started production in the second quarter of 1972. The zinc plant was originally designed to produce, annually, about 120,000 short tons of refined zinc metal, 230,000 tons of sulphuric acid, 1,000,000 pounds of cadmium, some cement copper and a silver-lead leach residue. Production of zinc metal during 1972 totalled 60,100 short tons. The plant reached more than 90 per cent of its design capacity in December. Because of a delay in delivery of equipment, cadmium metal production totalled only 173,000 pounds in 1972. The partially processed residues containing additional cadmium metal will be treated in 1973, in addition to the normal production. Sulphuric acid production was 120,000 tons. Planned conversion of the zinc plant production from batch leaching and purification to a



continuous operation is now under way and should be completed by mid-1974. This change plus various modifications to the acid plant and other minor changes at a total cost of about $5 million, should increase zinc metal production capacity by some 25 per cent, from an annual rate of 120,000 tons to about 150,000 tons. There will be corresponding increases in production capacity for the plant's other products. Sulphuric acid capacity will increase from 230,000 tons to about 285,000 tons per year, and cadmium metal from 1,000,000 pounds to 1,250,000 pounds per year. The intent is to make the zinc plant as fully automated and efficient as is possible. This will also include mechanical stripping, casting and stacking.

Cominco's zinc plant operated at near capacity for most of the year except in July when approximately one month of production was lost by a strike lasting from July 8 to 27. The company's first phase, $20 million modernization and expansion program completed by the end of 1971 was well timed to coincide with the excellent demand for Canadian metal throughout 1972. Currently the company is installing a battery of high capacity electrolytic zinc cells. This installation, which will produce an additional 10,000 tons of refined zinc at the Trail operations, will be completed at an estimated cost of $2.5 million. Future conversion to more high-capacity cells will then be considered.

Metal consumption. Producers' domestic shipments which measure apparent consumption were 137,699 tons in 1972 compared with 122,164 tons in 1971. Buoyant domestic consumption is likely to continue in 1973 as the continuation of excellent marketing conditions is forecast for the automobile industry and appliance industries. As shown in the tables, Statistics Canada measures consumption at the consumer level and consistently reports primary consumption below levels of shipments. It should also be noted that preliminary Statistics Canada figures are usually adjusted upwards. Increases in galvanizing accounted for most of the annual increase and die-casting uses remained steady but might be underestimated. Consumption of secondary zinc is less than 5 per cent of the total, which is considerably below U.S. levels and is expected to increase over the next few years.

World industry

Mine production. World mine production of zinc in 1972 increased by 164,000 tons to 4,880,552 tons which was slightly more than expected. Production in Canada, Australia, Peru, Mexico and Sweden increased modestly, but that of USA, Japan and West Germany declined. New mining projects now under completion have the potential of adding some 300,000 tons in 1973 and 1974 offset by a decline of some 100,000 tons in mine closures. In 1973 the largest expected increases will be from full production at the Mattabi mine and the new Ruttan mine in Canada. In the USA continued expansion is forecast for the Balmat-Edwards mines in New York State; in South Africa the New Prieska mine will produce at an annual rate of up to 40,000 tons of zinc by the end of 1973 and 80,000 tons by the end of 1974. In addition small mines will open in Japan, Peru, India, Morocco and USA. The largest annual zinc output of 90,000 tons is expected from Cominco's (Greenex) Black Angel mine in Greenland. By 1975-76 additional increases in Spain, Australia, Canada, Peru and Sweden might add another 80,000 to 100,000 tons of zinc. Beyond 1976 the only probable large development is the Navan mine of Tara Exploration and Development Company Limited in Ireland that has a producing potential of 200,000 to 240,000 tons per year. Peru, which by 1975 will extract about 400,000 tons annually, has reserves to increase production rapidly to 500,000 tons per year if financing can be arranged. All of these mine developments are necessary to ensure adequate supply to meet average demand forecast. Shortfalls in production or postponements of mine development might result in unprecedented shortages.

Table 8. World[1] mine production of zinc, 1970-72

	1970	1971	1972^p
	(st)	(st)	(st)
Canada	1,381,300^r	1,400,217	1,401,693
United States	586,980	540,022	529,991
Australia	492,512	459,663	519,960
Peru	362,660	343,259	368,172
Japan	308,316	324,520	309,740
Mexico	289,908	287,923	290,900
West Germany	151,788	162,480	150,906
Republic of Zaire	114,640	120,152	123,450
Italy	122,026	116,845	109,018
Sweden	98,106	105,381	121,034
Spain	105,271	101,413	100,751
Ireland	106,373	96,452	102,515
Yugoslavia	85,980	84,657	. .
Zambia	72,532	75,949	77,713
Finland	69,115	56,108	55,997
Other countries	445,222	433,318	611,015
Total	4,792,729	4,708,359	4,872,855

Sources: International Lead & Zinc Study Group. For Canada, Statistics Canada.

[1]Total figures in respect to "other" countries exclude data relating to Bulgaria, China, Czechoslovakia, East Germany, Poland, Romania, North Korea and the U.S.S.R.

[p]Preliminary; . . Not available; [r]Revised.

Metal production. World* metal production in 1972 totalled 4,577,417 tons, 9.8 per cent higher than in 1971. Producers' stocks at the begining of the year amounted to 370,000 tons and declined to 268,000 tons at the year's end. Stocks further declined to a new low of 232,000 tons by the end of the first quarter of 1973. Zinc smelters operated at or near their capacities almost everywhere except in Japan where some pollution problems curtailed production at one of the major smelters. However, the two newest and most modern Japanese electrolytic plants at Hikoshima (1971) and Iijima (1972) operated at full capacity.

The only important industrial countries that showed a continuing decrease in zinc production were Britain and the United States, which were still subject to closures of old, uneconomic smelters. The U.S. registered a 12-per-cent drop between 1970 and 1971, and a further 9.6 per cent in 1972. Of 23 countries reporting production to the International Lead and Zinc Study Group, 19 recorded increases of metal production, the largest being in Belgium, France, West Germany, Canada, Japan and Australia.

Table 9. World[1] production of refined zinc, 1970-72

	1970	1971	1972^p
	(st)	(st)	(st)
Japan	745,492	789,695	887,690
United States	954,931	847,346	765,444
Canada	455,471	410,643	524,885
West Germany	331,795	289,467	395,288
Australia	295,860	292,884	328,488
Belgium	255,626	229,170	278,995
France	246,917	241,075	284,506
Italy	156,638	153,882	162,370
Spain	103,727	107,034	113,538
Britain	161,599	128,419	77,162
Mexico	88,956	91,933	93,035
Finland	61,500	70,210	89,390
Norway	67,680	68,780	80,790
Republic of Zaire	70,548	69,446	69,446
Peru	78,264	64,595	69,776
Netherlands	51,690	48,500	53,240
Other countries	258,843	265,559	303,374
Total	4,385,537	4,168,638	4,577,417

Sources: International Lead & Zinc Study Group. For Canada, Statistics Canada.
[1]Total figures in respect to "other" countries exclude data relating to Bulgaria, China, Czechoslovakia, East Germany, Poland, Romania, North Korea and the U.S.S.R.
^{p}Preliminary.

*Excluding Communist countries.

Several smelter operators closed or announced closures of uneconomic plants. Dowa Mining Company closed its 21,000-ton-per-year plant at Kosaka in 1972 replacing it by the new Iijima plant which started at an initial capacity of 88,000 tons per year and will be expanded further by some 46,000 tons by 1975.

Preussag closed its Nordheim horizontal retort smelter of 45,000 tons per year capacity having commissioned its new electrolytic facility in the same locality. This plant will be further expanded from 88,000 tons per year to 115,000 tons per year by the end of 1973. Société de Prayon closed its 55,000-ton-per-year horizontal retort at Prayon and commissioned a new electrolytic facility just across the river at Eheim. This modern plant was built at low cost in record time and is likely to produce some 5,000 to 10,000 tons per year at better than its reported rated capacity of 55,000 tons.

In 1973 Belliton will close its horizontal retort at Budel, Holland replacing it with new electrolytic capacity and by 1974 a similar plant at Overpelt (Hoboken – Overpelt Co.) Belgium will close and will be replaced by 88,000 tons of new electrolytic capacity.

Mexico will increase its metal production considerably in 1973/74 and there is a possibility of a further expansion of the new Torreon refinery if mine output can be increased by 1976/77. Peru also plans completion of its new electrolytic plant at Lima by 1975. The country is giving top priority to this project since, besides zinc, it needs byproduct sulphuric acid production, partly for leaching the new Cerro Verde copper deposits.

Following the closure of six smelters in the United States between 1969 and the end of 1971, The Anaconda Company closed its large electrolytic plant at Great Falls, Montana in July 1972. American Metal Climax Inc. will close its Blackwell, Oklahoma horizontal retort plant by the end of 1973 and re-open its rehabilitated Sauget plant, East St. Louis, Illinois in 1973. The company bought this plant from the American Zinc Company in 1972. American Smelting and Refining Company (ASARCO) will close its Amarillo, Texas smelter in 1975 or possibly earlier if state air pollution legislation demands it. With the rapid decline in U.S. zinc smelting and refining capacity taking place, at least one company, ASARCO intends to build a 180,000-ton-per-year plant at Stephensport, Ky. If the project proceeds on time, one might expect the plant to be operational by 1976. ASARCO also announced that it will modernize and expand by 20 per cent its Corpus Christi electrolytic plant before 1975. In 1972 the company bought from The Anaconda Company a zinc fuming plant at East Helena. St. Joe Minerals Corporation also intends to expand the capacity of its Moneka, Pennsylvania plant by approximately 40,000 tons per year by 1975/76.

The accompanying table shows new and expanded smelter capacity planned up to 1976. Comparisons with data available for the 1971 review indicate that construction or completion dates for seven facilities have been deferred by one year. As mentioned previously the trend is to establish new capacity near industrial consuming centres. Not given in the table are foreseen increases beyond 1976; these could include modernization of three more plants in the United States and possibly further expansions in Canada and Australia and a new plant in Britain or Ireland. By the beginning of 1977 new plants may be operational in Thailand and Turkey.

		Type and Location of New and Expanded Smelter Capacity	Increase In Capacity (short tons per year)
1973	South Africa	Electrolytic (expansion), Vogelstuisbuilt	15,000
	Italy	ISF (new), Portovesme	77,000
	Japan	Vertical Retort (expansion), Miike	15,000
	Japan	Electrolytic (expansion), Hikoshima	26,000
	Algeria	Electrolytic (new), Ghazaouet	44,000
	Mexico	Electrolytic (new), Torreon	30,000
	Netherlands	Electrolytic (new), Budel (replacing 66,000)	110,000
	Yugoslavia	ISF (new), Tito Veles	55,000
	West Germany	Electrolytic (further expansion), Nordenham	27,000
	U.S.A.	Electrolytic (rehabilitated), Sauget, 11.	70,000
1974	Canada	Electrolytic (expansion), Timmins	30,000
	Australia	Electrolytic (expansion), Risdon	22,000
	Japan	Electrolytic (expansion), Kamioka	12,000
	Netherlands	Electrolytic (further expansion), Budel	55,000
	Belgium	Electrolytic (new), Overpelt (replacing 70,000)	88,000
	Mexico	Electrolytic (new, further expansion), Torreon	90,000
1975	Japan	Electrolytic (further expansion), Iijima	86,000
	Italy	Electrolytic (expansion), Crotona	44,000
	Spain	Electrolytic (expansion), San Juan	44,000
	Canada	Electrolytic (expansion), Valleyfield	80,000
	U.S.A.	Electrothermic (expansion), Monaka, Pa.	40,000
	U.S.A.	Electrolytic (expansion), Corpus Christi, Tex.	20,000
1976	India	Electrolytic (expansion), Zawar	20,000
	India	Electrolytic (new), Vizag	33,000
	Mexico	Electrolytic (new), San Luis Potosi	110,000
	India	Electrolytic (expansion), Kerala	22,000
	U.S.A.	Electrolytic (new), Stephensport, Ky.	180,000
	Peru	Electrolytic (new, first phase), Lima	40,000

Essentially, closures of uneconomic plants and deferments of new construction heralded a year ago as a move in the right direction to restore balance between supply and demand, have frequently been over compensating. However, the closure of old plants, modernization of existing facilities, the trend to hydrometallurgy in new plant construction and rationalization of marketing procedures will introduce a period of sound growth and good profitability for the zinc industry in the late seventies. The following tabulation indicates changes in zinc production processes:

Estimated Annual Production Capacity

Process	1970 short tons	% of total	1960 short tons	% of total
Hortizontal retort	807,000	15%	1,164,500	34.5%
Vertical retort	533,000	10	375,800	11
Electrothermic	367,000	6.5	249,000	7.5
Imperial smelting	686,500	12.5	68,300	2
Electrolytic	3,025,500	56	1,506,500	45
	5,417,000		3,364,100	

E/MJ, Feb. 1972

Between 1970 and 1978 electrolytic capacity will continue to replace other plant systems and will account for approximately 70 per cent of the total installed capacity by 1978.

Several significant improvements designed to help lower the cost and significantly upgrade recoveries have been made recently to the electrolytic process and are now being widely implemented. These are:

• Using fluid-bed roasters in preference to multiple hearth and flash-suspension types. The fluid-bed models produce large tonnages of good quality calcine and generally have lower operating and maintenance costs than the older types.

• Switching to continuous leaching. Previously, close control was obtained only by batch leaching. Now, as control equipment has improved, and as cost-cutting methods have been given priority, continuous leaching is gaining wider use.

• Jarosite process. In this method, which improves zinc recoveries during leaching, the ferrites which do not dissolve during low-acid strength leaching are dissolved in strong hot acid. Adding ammonia or alkali ions then precipitates very insoluble, complex and crystalline basic iron compounds. In addition to raising zinc recoveries by several per cent above the 90-93 per cent range during normal leaching, the jarosite process boosts recoveries of cadmium, copper, silver and lead. Expected zinc recovery in the most efficient plants is up to 97 per cent.

• Continuous purification of fluid-leach solution. This is being done in some electrolytic plants with instrument control and automatic reagent feeding, and is done for the same basic reason as that for adopting continuous leaching: minimum operating costs.

• Improved electrolysis. One improvement has been to handle the electrodes mechanically, making it possible for them to be larger, thereby increasing zinc yield. Another trend in the electrolytic section has been to arrange cell banks on the same level with solution flow in parallel through all cells, in contrast to the older practice where banks were arranged in cascades with a series solution flow. When the banks are at the same level, the electrolyte circulates between the cells and the cooling towers, with $ZnSO_4$ solution being added continuously to maintain a constant zinc content in the feed electrolyte.

• Improved cathode stripping. Normally stripped from the cathode by hand, zinc is now being removed by any of several methods, ranging from a variety of stripping machines to a hydraulic process and equipment for stripping with high-pressure jets. One plant, S.A. Vielle Montagne, Balen, Belgium, has gone one step further by installing an automated cell house complete with mechanical stripping machines.

• Use of casting machines and automatic stacking machines. This is the current trend, though hand-casting is still carried out in some electrolytic plants. Most new plants use a conveyor-type casting machine, and zinc pouring is an automated operation.

Consumption. World consumption of zinc in 1972 totalled 4,731,000 tons or 7.7 per cent higher than 1971. European consumption increased by 4.4 per cent, that of Japan by 12.7 per cent and that of the USA by 13.9 per cent. Of the 29 countries that reported consumption to the International Lead and Zinc Study Group, 22 showed increases in consumption for the year. Where results are available for the first quarter of 1973 the rising consumption trends appear to continue unabated.

World trade. The major consuming areas in the world, excluding countries with centrally planned economies, are western Europe, the United States and Japan, which among themselves used 3.96 million tons of zinc in 1972 or 84 per cent of the total world consumption. By contrast these areas produced only 1.67 million tons or 34.8 per cent of the world's mine output of zinc. The remaining requirements, approximating 2.28 million tons, were imported as either zinc concentrates or as refined metal. Except for the United States, this was mainly in the form of concentrates. In 1972 the major consuming areas as defined above produced 3.27 million tons of refined metal, i.e. 71 per cent of world production. This is 2 per cent less than in 1971, and results from decreasing metal output in USA. It illustrates the fact that most of the world's smelting and refining capacity is concentrated in industrialized areas where it must depend largely on imported concentrates. Canada, Peru, Australia and Mexico in that order are the largest exporters of zinc, jointly accounting for approximately 76 per cent of trade in concentrates and 41 per cent of trade in metal.

Table 10. United States zinc consumption by end-use, 1971-72

	1971	1972p
	(short tons)	
Galvanizing	474,752	488,050
Brass products	150,486	201,402
Zinc-base alloy	516,111	567,262
Rolled zinc	38,852	42,560
Zinc oxide	40,043	51,989
Other uses	33,815	27,269
Estimated undistributed consumption	–	50,100
Total	1,254,059	1,428,632

Source: U.S. Bureau of Mines, Mineral Industry Surveys, Zinc Industry in December 1972.
pPreliminary; – Nil.

Outlook

Zinc metal consumption, which suffered a sharp setback in 1970 and much of 1971, has since grown strongly, first in United States and then with some lag in Japan, Europe and other countries of the world. Zinc mine production has been rising more slowly but shipments to smelters were in balance since substantial inventories of concentrates were available for processing in 1972. Metal production moved sharply up in 1972 and by the end of the year reached full capacity utilization throughout the world. Supplies of zinc metal in 1973 including output from new plants, plus an additional release from U.S. stockpile of up to 220,000 tons were expected to meet a further increase in consumption, forecast rather modestly at about 4.5 per cent by the International Lead and Zinc Study Group. Early results of 1973 however did not bear out this assumption. We are now looking at a possible demand growth of up to 9.0 per cent and continuing conditions of very tight supplies for all of 1973 and for much of 1974. Furthermore metal production expectations were not mitigated by any possible setbacks such as strikes, difficulties in deliveries, or major operational plant problems; essentially no contingencies for less than almost total capacity utilization of all existing plants have been allowed. Since these expected shortages will drive zinc prices to new heights, fears have been expressed of the long-term threat of substitution, particularly in the die-casting industry. No doubt this substitution will occur but if we are to maintain adequate supplies of zinc for the rest of this decade it should be considered as a necessary development.

World smelting and refining capacity is currently undergoing a major shakeup. Closures of obsolete or uneconomical plants in the U.S., Britain, Japan, West Germany, Belgium and Canada, including conversions of some ISF plants, have been barely balanced by modernization, increases in capacity and construction of new electrolytic plants around the world. Between 1970 and the end of 1973 an estimated decrease in old capacity will occur in the noncommunist world equivalent to some 900,000 short tons, while during the same period 700,000 tons of new capacity will be installed. Deferments on construction or expansion projects in the past two years effectively postponed by about a year or more their completion dates. As a result of this rationalization and modernization of plants, it is expected that the apparent world plant capacity utilization will increase, and recoveries of zinc will also increase by some 2 to 4 per cent as mentioned previously. There will also be a long overdue trend towards more processing and refining in four major world zinc mining countries: Canada, Australia, Peru and Mexico. The Canadian export processing index, which is the proportion of exported metal to total zinc exports, is expected to increase from 35 in 1972 to 43 by 1975-76. By comparison the Australian index was 47 (1971). By 1976 the United States is expected to arrest the trend of declining zinc metal production in proportion to their consumption, stabilizing its outside demand for primary metal at about half or slightly more than half of their requirements. The United States remains sensitive about increasing their metal imports; the position of the industry being that imports of zinc concentrates are only "30 per cent as detrimental to the balance of payments as foreign refined metal." On the other hand no world importer should be insensitive to the contrary policies of world producers to achieve a steadily increasing proportion of exports based on domestic processing facilities.

A look at how supply and demand is likely to develop during 1975-1977, which is as far ahead as is realistic for this appraisal, would suggest continuing short supply under general conditions of moderate to strong economic growth. Only deteriorating, recession-prone conditions would let us surmise that a surplus of zinc might at anytime overhang the market. These tight supply market conditions are forecast even though it is recognized that the U.S. will make available most of its remaining stockpiled metal.

Zinc uses

Zinc is used to galvanize steel and to make castings, alloys, sheet, zinc oxide and other compounds.

In galvanizing, zinc is applied as an impervious, corrosion-resistant coating to iron and steel products to prevent rust. Galvanized sheet is used in industrial, agricultural and residential construction; for guard rails, culverts and signs in road construction; and for rocker panels and other vulnerable parts of automobiles. Galvanized reinforcing rods are used in the construction industry, and galvanized structural members in bridge construction to save on painting and maintenance costs. Wire, pipe and numerous other articles are galvanized where protection is required. In the automotive industry the usage of galvanized sheet has been relatively steady over the last eight years, averaging 160 to 170 pounds (using 11- to 12-lb of zinc) per vehicle, but has declined to approximately 100 to 120 pounds in the 1971 models. For 1972 models the level remained essentially the same as in 1971. For 1973 and 1974 consumption is expected to stabilize at this lower level or possibly at a slightly increased level because of the expanding availability of one-side galvanized sheet and consequently higher welding productivity. Zinc die-cast components might decrease considerably in the 1975 and future models.

Die-castings made of zinc-base alloys are used in the automotive industry for such parts as grilles, headlight and taillight assemblies, fender extensions, door and window hardware, carburettors and fuel pumps. The average automobile contains about 100 lb of zinc in these parts. Zinc-base die-castings are used as components in household appliances such as washing machines and refrigerators, and in plumbing and hardware supplies. The alloys most commonly used for die-castings are made of Special High Grade zinc (99.99 per cent or higher) to which is added 4 per cent aluminum, 0.04 per cent magnesium and up to 1 per cent copper. A new application which holds great promise is superplastic zinc alloy. It is a material containing 78 per cent zinc and 22 per cent aluminum, which behaves like a metal at normal temperatures and like a plastic when heated to just over 500°F for forming. It has excellent pressure vacuum forming characteristics with excellent deep drawing and elongation characteristics; it has very good electrical conductivity and is highly corrosion-resistant. It will take electroplating or painting. Principally because of its ductility it is called a superplastic alloy and will find use in pressed parts for the automobile and appliance industry.

Brass, a copper-zinc alloy containing as much as 40 per cent zinc, has many applications in the form of sheets and strips, tubes, wire, rods, castings and extruded shapes. Rolled zinc is used in Canada mainly for making dry-cell batteries in which zinc serves both as the negative pole of the cell and as the container. In Europe, rolled zinc is a popular roofing and roof-flashing material. Other uses of rolled zinc are as terrazzo strip and anticorrosion plates for boilers, dock pilings and ships' hulls. Zinc, in the form of 0.2 to 0.3 micron-size particles of zinc oxide, is finding increasing use as the major constituent of the paper coating for coated paper electrostatic copiers. Zinc oxide is also used in compounding rubber and in making rayon yarn, ceramic materials, inks, matches, and many other commodities.

Weather-resistant paints based on zinc oxide and zinc dust provide one of the most effective and durable protective coatings on outside surfaces, especially metallic. A new application is a two-coat paint system known as Zincrometal that can be hot-rolled on coiled steel. It is applied on a chromium base coating. This system is reported to have corrosion resistance similar to galvanized steel, and could replace it in some applications. It has, however, important limitations, since tests show that it gives little if any sacrificial protection on scratched surfaces or cut edges.

Zinc dust, which is a finely divided form of zinc metal, is used in the process of printing and dyeing textiles, in zinc-rich paints, in purifying fats and precipitating gold and silver from cyanide solutions. The more important industrial compounds of zinc are zinc sulphide, which in combination with barium sulphate forms the pigment lithopone; zinc sulphate, used in rayon fibre manufacture; and zinc chloride, a wood preservative.

The International Lead Zinc Research Organization, Inc. (ILZRO) is the main body assisting industry to find new uses for lead and zinc. Promotion and advertising of new zinc products and processes is carried on by the Zinc Institute, Inc., which opened a branch office in Toronto in 1968. The development of thin-walled die-castings and of improved zinc-based die-casting alloys has done much to expand the use of zinc as a die-casting metal in competition with alternative materials such as aluminum and plastics.

Research

Research activities at the Mines Branch, Department of Energy, Mines and Resources, Ottawa, were continued through 1972 on hot-dip galvanizing and zinc alloy development.

Galvanizing. Arrangements were completed with sponsoring groups to undertake a joint investigation with an outside laboratory on the galvanizing behaviour of silicon-containing steels. The objectives are to generate a better understanding of how silicon in semi-killed and killed steel products promotes accelerated galvanizing reactivity, and to find practical means of countering or controlling this undesirable behaviour. Initial Mines Branch effort has been concerned with the effect of steel-base pretreatment and of galvanizing parameters on the coating behaviour of some binary iron-silicon alloys and a commercial low-alloy high-strength steel. A potentially important practical finding is that, at silicon levels corresponding to that in silicon-killed steels, the galvanizing reactivity was significantly reduced with increasing bath temperature. Depending on the substrate material, the surface pretreatment applied before galvanizing, and the galvanizing temperature, moderate to large reductions in iron-zinc alloy thickness and improvements in coating structure and uniformity, were achieved. This work is continuing.

As part of a program to study the influence of the physical condition of the iron surface on the galvanizing reaction kinetics, the effects of crystallographic orientation and surface treatment in galvanizing iron single crystals have been investigated. Commercial single crystals with the basic (110), (100) and (111) orientations, which exhibited significantly different galvanizing reactivities in the prior work, were given various pre-galvanizing treatments to produce a range of surface roughness and hardness conditions. Orientation-related differences in reactivity were identically reproduced on all relatively smooth surfaces. On rougher surfaces, as produced by shot-blasting for example, the dependence of reactivity on orientation was significantly reduced. Surface work-hardening had no apparent effect on the galvanizing reaction. Research is being extended to more conclusively identify the effect of substrate crystallographic orientation.

Zinc alloy development. Work on Zn-Al casting alloys based on secondary zinc continued in attempts to locate and define the effects of lead on the corrosion resistance. Electron microscopy confirmed that the corrosion paths were through the zinc-rich phase at grain and interphase boundaries, but no correlation of these sites with lead distribution has been found.

Lead has been found to cause grain coarsening in these alloys. The hypereutectic alloys (>5% Aℓ) showed the greatest grain coarsening, the hypereutectic alloys less and eutectic alloys none. The effect appears to be connected with the nature of the primary phases and may also be influenced by the rate of solidification.

Prices

Canadian prices f.o.b. Toronto or Montreal averaged 18.54 cents per pound of zinc in 1972 compared with 16.12 cents per pound in 1971. Comparative world prices are as follows:

	Canada cents/lb	United States cents/lb	Producer basis (outside North America) £/metric ton	London Metal Exchange £/metric ton
	1972	1972	1972	1972
Jan	17.0	17.0	150.00	147.71
Feb	17.0	17.0	150.00	149.69
Mar	17.8	17.3	150.00	151.66
Apr	18.0	17.5	150.00	151.34
May	19.0	17.9	150.00	147.91
June	19.0	18.0	150.00	144.05
July	19.0	18.0	159.05	148.89
Aug	19.0	18.0	160.00	148.42
Sept	19.0	18.0	160.00	150.89
Oct	19.0	18.0	160.00	151.85
Nov	19.2	18.0	162.95	161.09
Dec	19.5	18.1	173.00	159.92
Year	18.5	17.7	156.25	151.12

The end of 1972 was the beginning of a price rise that accelerated in the first three months of 1973 and is likely to continue. LME prices that consistently fluctuated below producer basis price in Europe crossed to a premium situation in February 1973. Tight supplies will accentuate this spread for the remainder of the year.

Lower prices in the United States, for the last half of 1972 and first quarter of 1973 are the result of price controls. The U.S. zinc industry is attempting to have zinc classified as an international commodity and thus be removed from price controls but as yet with little success.

Tariffs

The following Canadian and United States tariffs apply for zinc in its various forms.

Canada Item No.	British Preferential and Most Favoured Nation – all free	General
32900-1	Zinc in ores and concentrates	free
34505-1	Zinc spelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals, in the form of pigs, slabs, dust or granules/lb	2¢
34500-1	Zinc dross and zinc scrap for remelting, or for processing into zinc dust	10%
35800-1	Zinc anodes	10%

United States

Item No.		(¢/lb)
602.20	Zinc ores and concentrates, on zinc content	
	Unwrought zinc	0.67
626.02	Other than alloys of zinc	0.7
626.10	Zinc waste and scrap	0.75
603.30	Zinc dress and skimmings	0.75
		(%)
626.04	Alloys of zinc	19
653.25	Zinc anodes	
	On and after Jan. 1, 1970	13
	1971	11
	1972	9.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972) TC Publication 452.

Statistical Tables

GENERAL REVIEW STATISTICAL SUPPLEMENT

The statistics presented in the statistical supplement are chiefly derived from Statistics Canada sources. Certain information is obtained from other departments and from recognized international statistical sources.

The purpose of the supplement is to present in a comprehensive manner statistical data pertaining to Canada's mining and mineral industries. This is done within a framework of ten sections, each composed of a number of tables. An attempt is made to present all relevant general statistics which are of importance in understanding the role of the mining and mineral industries in the Canadian economy. Information relating to specific mineral commodities or segments of the mineral industry is found not in the supplement but in separate mineral commodity analyses within this volume. The main body of statistical tables of the supplement is preceded by a table on general economic indicators for Canada, covering the years 1951 to 1972 inclusive.

Section 1 Production – Tables 1 to 12

This section of 12 tables covers various aspects of mineral production. In Table 1 are found production statistics in terms of quantities and values, for some 60 individual minerals. This is an historical series, dating back to 1886, and relates to minerals produced from Canadian resources. Recoveries from secondary materials and imported ores and concentrates are not included.

The endeavour, in the computation of the quantities and values of the minerals recorded in this table, is to measure the components as close to the producing operation as feasible. In the case of nonmetallic minerals, quantities shipped plus values fob mine or mill, as reported by the producer, are taken as production. Mine shipments, with company stated values, are also taken to reflect production in the case of certain metals. The computation of quantity and value production statistics, however, for some metals is more complicated. Some metallic ores and concentrates produced in Canada's mines are treated at smelting and refining operations in Canada. The quantities of metals obtained from the processing of these materials are recorded and valued using average metal prices. However, some ores and concentrates are not treated in Canada but are shipped to foreign smelters for processing. In cases of this nature, the metal contents are computed, and from these quantities certain deductions for smelter and refinery losses are made in order to obtain recoverable metal contents. Average unit metal prices are then used in conjunction with recoverable metal calculations to arrive at production values.

Tables 2 to 7 are various historical tables based on Table 1, but none is on the Standard Industrial Classification (SIC) or Standard Commodity Classification (SCC) basis. Table 11 is a series showing physical volume indexes of the mining and mineral manufacturing industries. The indexes are computed in a manner that permits a reflection of changes in volume without the distorting influence of price factors. These indexes are compiled on the Standard Industrial Classification basis, and are presented in the table, unadjusted for seasonal variation, and on the base year 1961 being equal to 100. Table 8 shows Canada's position in the world as a producer of important minerals. Statistics for Canada are production data from Statistics Canada and are contained in Table 1 in this section. World totals and individual country totals, other than for Canada, are obtained from recognized international mineral publications, such as the *American Bureau of Metal Statistics*, and *United States Bureau of Mines*. Tables 9 and 10 report values added on the Standard Industrial Classification basis. The value added concept enables meaningful inter-industry comparisons, since duplicating cost factors, such as cost of materials used, fuel and electricity are removed. Table 12 shows real domestic product by industries.

This Statistical Supplement was prepared by B.F. Burke and Staff, Statistics Section, Mineral Development Sector.

Section 2 Trade – Tables 13 to 19

This section of seven tables covers Canada's trade in minerals and mineral products. These data are extracted from the publications of the External Trade Division of Statistics Canada. The values of exports and imports of crude minerals essentially refer to mine products. Mineral products consist of products of varying degrees of the manufacturing process, from primary refinery to more advanced products of rolling mills and other processing establishments. This class of mineral products includes fully fabricated products, which are used in the construction or fabrication of more advanced end-use products. Fully fabricated end-use products of a mineral origin, such as machines composed of ferrous or nonferrous metals, are not included under the class of fabricated products reported in this section. The values are based on information appearing on customs import and export entries. Export entries define the value of imports as the actual amount received or to be received in terms of Canadian dollars, exclusive of all charges such as freight, insurance and handling. Generally this definition gives values, fob point of consignment. The requirement under the Canadian Customs Act generally is for the evaluation of goods, fob point of shipment in the country of export.

Section 3 Consumption – Tables 20 to 22

In this section, composed of three tables, an attempt is made to relate Canadian consumption of the main crude minerals to domestic production of these minerals. The relationship of consumption as a per cent of production facilitates the determination of surpluses and shortages in the mineral commodities covered. Consumption data in Tables 20 and 21 are summations of quantities reported to Statistics Canada on special annual mineral consumption surveys. The production totals are those reported in Table 1 of Section 1. Table 21 shows, for certain minerals, the relationship between apparent consumption and production. Reported consumption for these minerals is not readily available. Therefore, apparent consumption which consists of an arithmetical calculation of production plus imports less exports, with no adjustments for stocks, indicates Canadian consumption requirements for these minerals. Table 22 gives annual production and consumption of certain important nonferrous refined metals. Consumption of these metals is reported by consumers to Statistics Canada, through special consumption surveys. Production of refined metals includes metal derived from all sources, including that from domestic ores and concentrates, from imported ores and concentrates and from secondary materials. Refined production of the metals in this table is reported in the respective commodity sections.

Section 4 Prices – Tables 23 to 26

This section comprises four statistical tables. Annual average price data shown in Table 23 are, with the exception of gold, obtained from *Metals Week* and are in United States currency.

The gold price, in Canadian currency, is the average annual Royal Canadian Mint buying price. The wholesale price indexes, reported in Tables 24 and 25 are compiled by the Prices Division of Statistics Canada. Wholesale price indexes (base 1935-39-100) of specific mineral products are shown in Table 24, while an historical series of wholesale price indexes for overall groups of mineral products and nonmineral products is shown in Table 25. Table 26 reports industry selling price indexes. These indexes differ from those of Tables 24 and 25 in that they measure the selling price levels of products within an industry.

Section 5 Principal Statistics – Tables 27 to 34

These tables outline principal statistics in the mining and mineral manufacturing industries. In Table 27, statistics relating to production and related workers, costs of fuel and electricity and materials and supplies are given by types of mining. Gross values of production, together with net values or values added of production, are shown. The values added totals are gross values with certain cost factors, such as costs of fuel and electricity, and cost of materials and supplies, removed. The mineral manufacturing industries are covered in Table 28, which includes the same statistical coverage as in Table 27. The values added totals for the mining and mineral manufacturing industries are also reported in Table 10. Tables 31 to 34 report component detail on the consumption of fuel and electricity by the mining and mineral manufacturing industries.

Section 6 Labour, Labour Costs, Wage Rates – Tables 35 to 46

Tables 35 and 36 of this section show employment and salaries and wage data for the mining and mineral manufacturing industries. Table 37 reports employment data for wage earners only. These employment figures are included in the overall totals of Table 35. Table 38 shows productivity information in respect to tons mined per worker and wage cost per ton mined for certain types of metal mining.

In Table 39, man-hours paid per ton mined in metal and industrial mineral operations are presented for a number of years. These are calculated totals, with the basic statistics being obtained from relevant Statistics Canada reports, and also, where necessary, from mining schedules received by SC. The wage rates shown in Table 40 are obtained from mining operators by the Department of Labour, and reported in the publication *Wage Rates, Salaries and Hours of Labour*. The index numbers of average wage rates reported in Table 41 are also obtained from this source. Average weekly wages and hours of hourly rated employees shown in Tables 42 and 43 are obtained from SC monthly and annual publications on man-hours and average earnings by industries. Information contained in Tables 44 and 45 on industrial fatalities and strikes and lockouts, by industries, is obtained from *Labour Gazette*, a publication of the federal Department of Labour. Table 46 shows data, by industries, on strikes and lockouts in Canada, and is from the Department of Labour compilations.

Section 7 Mining, Exploration, Drilling – Tables 47 to 56

In this section, operations of the mines are brought into perspective, by showing tonnages of ore mined and rock quarried by types of mining operations. Amounts expended in mining exploration and development by province are shown in Tables 49 and 50. These amounts are reported by provinces and this reflects where both exploration and development funds are being expended. Table 51 reports, in footages, by main types of mineral deposits, diamond drilling carried out both by drilling contractors and by mining companies with their own equipment. From 1964 those mining companies that are not yet in production have been excluded from the tabulation. Exploration diamond drilling only by producing companies and by contractors is reported in Table 53, and drilling other than exploration is covered in Table 54. Data in these tables are included in the totals of Tables 50 and 51. Table 55 covers operations of diamond drilling contractors only. The footages reported here represent total drilling by the contractors in mining operations and, to some extent, in nonmining operations. Contract drilling for oil and gas by type of drilling and also gross income and employment are reported in Table 56. Data for the tables in this section are obtained from the SC mining publications and, in some cases, from basic schedules. The SC report "*Contract Drilling for the Mining Industry*" is the basis of statistical data presented on contract drilling.

Section 8 Transportaion – Tables 57 to 63

In this section an endeavour has been made to emphasize the role that minerals and mineral products have in various types of transportation. For example, in Tables 57 and 58 the tonnages of crude mineral products moved by Canadian railways are shown, while Table 59 shows the importance of fabricated mineral products in total railway revenue freight. Crude minerals and fabricated mineral products transported through the St. Lawrence Seaway, in relation to total freight moved, are shown in Table 60. Tables in this section were derived from published data of the Transportation and Public Utilities Division of Statistics Canada and the St. Lawrence Seaway authority. Tables 61, 62 and 63 report tonnages of minerals and mineral products transported in coastwise and international shipping.

Section 9 Taxation – Tables 64 to 66

Tables 64 and 65 report the taxes paid by the main sectors of the mining industry to the three levels of government, federal, provincial and municipal. These data are extracted from the published mining industry reports of Statistics Canada.

Data in Table 66, reporting taxes paid by mining and mineral fabricating companies were extracted from *Industrial Corporations*, a publication of Statistics Canada. Taxes shown in Table 66 will not necessarily agree with those of Tables 64 and 65, chiefly because of differences in coverage and interpretation. Amounts shown in Tables 64 and 65 refer to actual payments made, while those of 66 are expressions of taxation levies.

Section 10 Investment, Finance – Tables 67 to 73

Tables 67 to 69 of this section are various breakdowns on capital and repair expenditures of the mining and mineral fabricating industries.

Capital invested on new construction and machinery and amounts expended on repair of existing structures and machinery are reported for the mining and mineral fabricating industries. These data are extracted from the Statistics Canada publication *Private and Public Investment in Canada.* Information shown in Table 70 refers to investment in all aspects of the oil and gas industries and is from a special tabulation prepared in the Business Finance Division of Statistics Canada. Tables 71 and 72 pertain to the degree of nonresident ownership of the mining and mineral manufacturing industries in Canada, and are prepared from data appearing in the publication entitled "*Corporations and Labour Unions Returns Act, Part 1*", published by the Corporation and Labour Unions Return Division of Statistics Canada.

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		1951	1952	1953	1954	1955	1956	1957	1958	1959
Gross National Product current prices	$ millions	21,640	24,588	25,833	25,918	28,528	32,058	33,513	34,777	36,846
Gross National Product 1961 price	"	25,673	27,968	29,408	29,047	31,788	34,474	35,283	36,098	37,470
Value of manufacturing industry shipments	"	..	..	..	..	19,513	21,637	22,178	22,171	23,353
Value of mineral production	"	1,245	1,285	1,336	1,488	1,795	2,085	2,190	2,101	2,409
Merchandise exports	"	3,897	4,282	4,097	3,860	4,258	4,760	4,789	4,791	5,022
Merchandise imports	"	4,005	3,916	4,248	3,967	4,568	5,547	5,473	5,050	5,509
Balance of trade, current account	"	+517	+151	+443	+432	+698	+1,366	+1,455	+1,131	+1,504
Corporation profits before taxes	"	2,800	2,640	2,611	2,290	2,965	3,345	3,056	3,075	3,504
Capital investment, current prices	"	4,424	5,424	5,968	5,802	6,531	8,196	8,813	8,488	8,500
Capital investment, 1961 prices	"	5,047	6,073	6,682	6,458	7,068	8,439	8,944	8,634	8,568
Population	000's	14,009	14,459	14,845	15,287	15,698	16,081	16,610	17,080	17,483
Labour	"	5,223	5,324	5,397	5,493	5,610	5,782	6,008	6,137	6,242
Employed	"	5,097	5,169	5,235	5,243	5,364	5,585	5,731	5,706	5,870
Unemployed	"	126	155	162	250	245	197	278	432	372
Unemployment rate	%	2.4	2.9	3.0	4.6	4.4	3.4	4.6	7.0	6.0
Employment index	1961 – 100	92.3	94.7	96.2	93.2	95.4	101.9	100.0	100.4	100.2
Labour income	$ millions	10,103	11,208	12,110	12,432	13,215	14,719	15,825	16,180	18,309
Index industrial production	1961 – 100	62.7	65.3	70.1	70.0	77.7	85.8	87.2	86.7	94.2
Index manufacturing production	"	68.9	71.5	76.6	74.9	82.2	89.9	89.7	88.0	94.5
Index mining production	"	43.6	46.5	50.6	56.1	66.4	77.1	84.6	86.0	97.3
Index real domestic product	"	67.3	72.5	75.5	74.3	82.1	89.1	89.5	91.0	95.7
General wholesale price index	1935-39-100	240.2	226.0	220.7	217.0	218.9	225.6	227.4	227.8	230.6
Consumer price index	1961 – 100	88.0	90.2	89.4	89.5	90.1	91.4	94.3	96.8	97.9

.. Not available.
p Preliminary.
r Revised.

indicators, 1951-1972

1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972[p]
38,359	39,646	42,927	45,978	50,280	55,364	61,828	66,409	72,586	79,815[r]	85,610[r]	93,402	103,407
38,553	39,646	42,349	44,531	47,519	50,685	54,207	56,016	59,292	62,448[r]	64,046[r]	67,782	71,722
23,444	24,428	26,713	28,741	31,560	33,889	37,303	38,955	41,997	45,110	45,991	49,130	53,749
2,493	2,603	2,881	3,027	3,365	3,715	3,981	4,391	4,722	4,736	5,722[r]	5,968	6,417
5,256	5,755	6,179	6,799	8,094	8,525	10,071	11,112	13,270[r]	14,498[r]	16,491[r]	17,424	19,500
5,482	5,769	6,258	6,558	7,487	8,633	9,866	11,075	12,366	14,130	13,939[r]	15,607	18,736
−1,243	−982	−830	−521	−424	−1,130	−1,162	−499	−107	−952	+1,036[r]	+397	−584
3,359	3,427	3,819	4,188	4,819	5,199	5,145	5,020	6,142	6,527	5,943	6,822	
8,328	8,292	8,769	9,398	10,980	12,935	15,088	15,348	15,455	16,927	17,798	20,184	21,877
8,281	8,292	8,632	9,020	10,253	11,515	12,820	12,993	12,880	13,560	13,840	14,422	14,915
17,870	18,238	18,583	18,931	19,290	19,644	20,015	20,405	20,744	21,061	21,377	21,568	21,830
6,411	6,521	6,615	6,748	6,933	7,141	7,420	7,694	7,919	8,612	8,374	8,631	8,891
5,965	6,055	6,225	6,375	6,609	6,862	7,152	7,379	7,537	7,780	7,879	8,079	8,329
446	466	390	374	324	280	267	315	382	382	495	552	562
7.0	7.1	5.9	5.5	4.7	3.9	3.6	4.1	4.8	4.7	5.9	6.4	6.3
100.7	100.0	102.2	104.4	108.2	114.3	120.7	122.6	122.7	126.9	127.1	127.8	129.9
19,303	20,136	21,597	23,057	25,219	28,181	31,907	35,275	38,493	43,203	47,036	46,633	51,260
96.2	100.0	108.3	115.2	126.6	137.0	146.0	150.8	161.9[r]	172.6[r]	175.3[r]	184.2[r]	196.8
96.1	100.0	109.0	116.2	127.4	138.8	148.7	152.3	163.6[r]	175.4[r]	173.0[r]	181.7[r]	193.9
97.4	100.0	106.2	112.1	126.0	131.9	134.2	142.1	152.4	153.5[r]	175.3[r]	182.9[r]	191.8
98.0	100.0	106.9	112.7	120.4	129.0	138.0	142.4	152.5[r]	161.6[r]	165.6[r]	175.0[r]	184.3
230.9	233.3	240.0	244.6	245.4	250.3	259.5	264.1	269.9	282.4	286.4	289.9	310.3
99.1	100.0	101.2	103.0	104.8	107.4	111.4	115.4	120.1	125.5	129.7	133.4	139.8

Table 1. Mineral production of Canada, 1971 and 1972 and average 1968-1972

	Unit of Measure	1971		1972P		Average 1968-1972	
		Quantity	$000	Quantity	$000	Quantity	$000
Metals							
Antimony	000 lb	324	244	470	290	700	552
Bismuth	" "	271	1,398	256	919	468	2,135
Cadmium	" "	4,064	7,884	3,924	9,927	4,505	13,158
Calcium	" "	355	292	477	342	537	482
Cobalt	" "	4,323	9,430	4,151	10,234	4,064	9,082
Columbium (Cb_2O_5)	" "	2,333	2,297	3,900	4,000	3,305	3,265
Copper	000 st	721	760,016	802	810,976	680	709,292
Gold	" troy oz	2,261	79,903	2,079	119,626	2,407	97,390
Iron ore	" lt	42,279	555,136	43,710	517,150	41,227	529,537
Iron remelt	" st	..	30,824	..	38,353	..	29,887
Lead	"	406	109,488	371	114,557	365	107,059
Magnesium	000 lb	14,467	5,164	11,688	4,548	17,599	6,060
Molybdenum	" "	22,663	38,367	24,844	34,022	26,679	44,047
Nickel	" st	294	800,064	258	702,126	267	668,330
Platinum group	" troy oz	475	39,821	399	33,854	431	38,863
Selenium	" lb	718	6,531	655	5,836	654	4,916
Silver	" troy oz	46,024	71,797	48,488	80,489	45,461	84,456
Tantalum	" lb	450	2,901	325	2,307	305	2,099
Tellurium	"	24	148	48	288	52	332
Thorium	"	–	–	–	–	84	158
Tin	"	319	421	361	657	318	494
Tungsten, (WO_3)	"	4,624	..	4,956	..	4,191	..
Uranium (U_3O_8)	"	8,214	..	9,796	..	8,266	..
Zinc	" st	1,250	418,161	1,324	504,851	1,238	403,332
Total metals	"	..	2,940,287	..	2,995,352	..	2,754,926
Nonmetals							
Arsenious oxide	000 lb	100	11	60	7	266	23
Asbestos	000 st	1,635	203,999	1,692	219,700	1,639	202,416
Barite	"	121	1,061	73	650	124	1,148
Feldspar	" st	11	216	10	200	11	250
Fluorspar	" st	..	2,819	..	5,300	..	3,671
Gemstones	" lb	168	196	170	196	110	139
Gypsum	" st	6,702	15,083	7,942	18,070	6,653	14,835
Magnesite dolomite and brucite	" st	..	2,673	..	2,555	..	2,963
Nepheline	" st	517	6,206	560	7,065	498	5,949
Peat moss	" st	337	11,803	370	13,160	330	10,670
Potash (K_2O)	" st	4,000	134,955	4,130	140,500	3,592	103,731
Pyrite pyrophyllite	" st	318	1,162	130	495	300	1,572
Quartz	" st	2,554	7,411	2,700	8,750	2,669	6,991
Salt	" st	5,542	40,111	5,535	43,110	5,192	36,179
Soapstone, talc, pyrophyllite	" st	66	1,060	80	1,535	75	1,183
Sodium sulphate	" st	482	7,064	503	6,139	491	7,188
Sulphur in smelter gas	" st	618	4,633	630	5,223	659	6,831
Sulphur, elemental	" st	3,149	21,300	3,271	18,593	3,105	41,787
Titanium dioxide, etc.	" st	..	39,064	..	41,105	..	34,634
Total nonmetals			500,827		532,353		482,160

Table 1. (concl'd)

	Unit of Measure	1971		1972P		Average 1968-1972	
		Quantity	$000	Quantity	$000	Quantity	$000
Fuels							
Coal	000 st	18,432	121,727	20,709	149,651	15,481	92,399
Natural gas	" mcf	2,499,024	342,549	2,913,047	388,500	2,272,758	306,866
Natural gas byproducts	" bbl	85,678	193,191	106,947	245,412	79,149	172,538
Petroleum crude	"	492,739	1,356,943	562,452	1,571,800	461,370	1,207,411
Total fuels		..	2,014,410	..	2,355,363	..	1,779,214
Structural materials							
Clay products	$000	..	48,583	..	48,998	..	49,518
Cement	000 st	9,067	191,244	10,010	210,340	8,688	173,525
Lime	" st	1,598	23,486	1,606	23,891	1,594	21,094
Sand and gravel	" st	213,291	152,628	215,600	155,900	207,673	138,749
Stone	" st	73,515	96,537	74,200	95,250	71,291	92,721
Total structural materials			512,478		534,379		475,607
Total all minerals			5,968,002		6,417,447		5,491,907

Symbols: .. Not available or not applicable; —Nil; pPreliminary.

Notes:
1. Production statistics for the following are not available for publication: indium, mercury, helium, nitrogen, diatomite, yttrium.
2. Nil production for the following between 1968 and 1972: grindstone, iron oxide, lithia, mica.
3. Dollar values only available for publication for the following: iron remelt, fluorspar, magnesite, dolomite and brucite, titanium dioxide, clay products.
4. Quantities only available for publication for the following: tungsten, uranium.

Table 2. Canada, values of mineral production, per capita values of mineral production and population, 1932-1972

	Metallics $ million	Industrial Minerals $ million	Fuels $ million	Total $ million	Per Capita Value of Mineral Production $	Population of Canada 000
1932	112	30	49	191	18.20	10,510
1933	147	27	48	222	20.85	10,633
1934	194	30	54	278	25.91	10,741
1935	222	36	55	313	28.84	10,845
1936	260	43	60	363	33.11	10,950
1937	335	57	66	458	41.48	11,045
1938	324	54	65	443	39.71	11,152
1939	343	61	71	475	42.12	11,267
1940	382	69	79	530	46.55	11,381
1941	395	80	85	560	48.69	11,507
1942	392	83	92	567	48.63	11,654
1943	357	80	93	530	44.94	11,795
1944	308	81	97	486	40.67	11,946
1945	317	88	94	499	41.31	12,072
1946	290	110	103	503	40.91	12,292
1947	395	140	110	645	51.38	12,551
1948	488	172	160	820	63.97	12,823
1949	539	178	184	901	67.01	13,447
1950	617	227	201	1,045	76.24	13,712
1951	746	266	233	1,245	88.90	14,009
1952	728	293	264	1,285	88.90	14,459
1953	710	312	314	1,336	90.02	14,845
1954	802	333	353	1,488	97.36	15,287
1955	1,008	373	414	1,795	114.37	15,698
1956	1,146	420	519	2,085	129.65	16,081
1957	1,159	466	565	2,190	131.87	16,610
1958	1,130	460	511	2,101	122.99	17,080
1959	1,371	503	535	2,409	137.79	17,483
1960	1,407	520	566	2,493	139.48	17,870
1961	1,387	542	674	2,603	142.72	18,238
1962	1,496	574	811	2,881	155.05	18,583
1963	1,510	632	885	3,027	159.91	18,931
1964	1,702	690	973	3,365	174.45	19,290
1965	1,908	761	1,046	3,715	189.11	19,644
1966	1,985	844	1,152	3,981	198.88	20,015
1967	2,285	861	1,235	4,381	214.69	20,405
1968	2,493	886	1,343	4,722	227.64	20,744
1969	2,378	893	1,465	4,736	224.87	21,061
1970	3,073	931[r]	1,718	5,722[r]	267.67[r]	21,377
1971	2,940	1,014	2,014	5,968	276.71	21,568
1972[p]	2,995	1,067	2,355	6,417	290.49	21,830

[p]Preliminary.
[r]Revised.

Table 3. Canada, value of mineral production by provinces and mineral classes, 1972[p]

	Metals		Industrial Minerals		Fuels		Total	
	$000	% of Total	$000	% of Total	$000	% of Total	$000	% of Total
Alberta	–	–	65,708	6.2	1,892,095	80.3	1,957,803	30.5
Ontario	1,271,906	42.5	262,904	24.7	7,379	0.3	1,542,189	24.0
Quebec	421,542	14.0	357,625	33.5	28	–	779,195	12.1
British Columbia	401,455	13.4	89,004	8.3	182,327	7.8	672,786	10.5
Saskatchewan	22,595	0.8	161,882	15.2	236,251	10.0	420,728	6.6
Manitoba	265,234	8.8	32,200	3.0	14,509	0.6	311,943	4.9
Newfoundland	274,051	9.2	29,800	2.8	–	–	303,851	4.7
Northwest Territories	130,551	4.4	–	–	2,432	0.1	132,983	2.1
New Brunswick	114,037	3.8	14,468	1.4	3,581	0.2	132,086	2.1
Yukon	93,981	3.1	14,200	1.3	276	–	108,457	1.7
Nova Scotia	–	–	38,141	3.6	16,485	0.7	54,626	0.8
Prince Edward Island	–	–	800	–	–		800	–
Total	2,995,352	100.0	1,066,732	100.0	2,355,363	100.0	6,417,447	100.0

[p]Preliminary; –Nil.

Table 4. Canada, production of leading minerals by

	Unit of Measure	Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario
Petroleum	000 bbl	–	–	–	9	–	878
	$000	–	–	–	13	–	2,504
Copper	st	10,620	–	–	9,473	172,190	288,231
	$000	10,744	–	–	9,583	174,188	291,563
Nickel	st	–	–	–	–	158	189,073
	$000	–	–	–	–	447	513,301
Iron ore	000 st	18,355	–	–	–	11,267	12,802
	$000	245,136	–	–	–	99,253	161,281
Zinc	st	27,600	–	–	207,268	157,552	409,970
	$000	10,527	–	–	79,056	60,090	156,370
Natural gas	000 Mcf	–	–	–	97	187	12,187
	$000	–	–	–	84	28	4,875
Asbestos	000 st	69	–	–	–	1,374	37
	$000	13,000	–	–	–	165,400	4,400
Cement	000 st	..	–	..	..	3,214	3,743
	$000	2,564	–	4,759	4,232	63,036	71,611
Sand and gravel	000 st	4,400	1,500	6,000	5,000	42,000	80,000
	$000	5,700	800	6,300	2,700	20,200	60,000
Coal	000 st	–	–	1,425	430	–	–
	$000	–	–	16,485	3,484	–	–
Potash (K_2O)	000 ST	–	–	–	–	–	–
	$000	–	–	–	–	–	–
Gold	000 oz	17	–	–	3	567	1,008
	$000	978	–	–	173	32,625	58,000
Lead	st	17,250	–	–	51,874	1,693	10,378
	$000	5,322	–	–	16,003	522	3,202
Stone	000 st	200	–	1,700	1,500	37,250	29,000
	$000	600	–	3,100	3,000	42,250	39,000
Silver	000 oz	810	–	–	5,430	3,542	20,234
	$000	1,344	–	–	9,013	5,880	33,588
Clay products	$000	80	–	1,649	656	8,075	28,907
Salt	000 st	–	–	800	–	–	4,150
	$000	–	–	8,625	–	–	27,850
Titanium dioxide	st	–	–	–	–	..	–
	$000	–	–	–	–	41,105	–
Iron remelt	st	–	–	–	–	..	–
	$000	–	–	–	–	38,353	–
Molybdenum	000 lb	–	–	–	–	869	–
	$000	–	–	–	–	1,477	–
Platinum metals	000 oz	–	–	–	–	–	399
	$000	–	–	–	–	–	33,854
Lime	000 st	–	–	–	..	294	1,095
	$000	–	–	–	293	3,897	15,846
Sulphur elemental	000 st	–	–	–	–	–	45
	$000	–	–	–	–	–	833
Gypsum	000 st	600	–	5,990	75	–	664
	$000	1,746	–	13,088	250	–	1,450
Total leading minerals	$000	297,741	800	54,006	128,540	756,826	1,508,435
Total all minerals	$000	303,851	800	54,626	132,086	779,195	1,542,189
Leading minerals as % of all minerals		98.0	100.0	98.9	97.3	97.1	97.8

[p]Preliminary; –Nil; . .Not available.

provinces and territories, 1972p

Manitoba	Sask.	Alberta	B.C.	Y.T.	N.W.T.	Total Canada
5,257	86,599	444,984	23,835	–	890	562,452
14,509	218,230	1,272,343	63,044	–	1,157	1,571,800
58,511	13,139	–	247,855	1,069	602	801,690
59,187	13,291	–	250,730	1,081	609	810,976
65,571	–	–	1,665	1,620	–	258,087
179,050	–	–	4,730	4,598	–	702,126
–	–	–	1,286	–	–	43,710
–	–	–	11,480	–	–	517,150
45,925	16,575	–	133,757	115,000	210,000	1,323,647
17,516	6,322	–	51,015	43,861	80,094	504,851
–	68,518	2,385,311	432,185	2,594	11,968	2,913,047
–	8,640	329,888	43,434	276	1,275	388,500
–	–	–	108	104	–	1,692
–	–	–	22,700	14,200	–	219,700
550	169	938	885	–	–	10,010
14,838	4,401	21,096	23,803	–	–	210,340
16,700	10,000	18,500	31,500	–	–	215,600
12,200	6,000	16,000	26,000	–	–	155,900
–	3,283	9,024	6,547	–	–	20,709
–	6,552	51,063	72,067	–	–	149,651
–	4,130	–	–	–	–	4,130
–	140,500	–	–	–	–	140,500
40	31	–	121	4	288	2,079
2,302	1,784	–	6,962	230	16,572	119,626
194	–	–	93,983	112,960	83,000	371,332
60	–	–	28,994	34,848	25,606	114,557
1,000	–	200	3,350	–	–	74,200
1,000	–	800	5,500	–	–	95,250
814	401	–	7,238	5,620	4,399	48,488
1,351	665	–	12,015	9,330	7,303	80,489
374	1,409	4,507	3,341	–	–	48,998
31	250	304	–	–	–	5,535
135	3,920	2,580	–	–	–	43,110
–	–	–	–	–	–	..
–	–	–	–	–	–	41,105
–	–	–	–	–	–	..
–	–	–	–	–	–	38,353
–	–	–	23,975	–	–	24,844
–	–	–	32,545	–	–	34,022
–	–	–	–	–	–	399
–	–	–	–	–	–	33,854
..	–	120	..	–	–	1,606
1,016	–	2,374	465	–	–	23,891
4	25	3,139	58	–	–	3,271
111	247	17,072	330	–	–	18,593
180	–	–	433	–	–	7,942
346	–	–	1,190	–	–	18,070
303,995	411,961	1,717,723	660,345	108,424	132,616	6,081,412
311,943	420,728	1,957,803	672,786	108,457	132,983	6,417,447
97.5	97.9	87.7	98.2	99.9	99.7	94.8

Table 5. Canada, percentage contribution of leading minerals to total value of mineral production 1963-1972

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972[p]
Petroleum	20.9	20.0	19.4	19.8	19.8	19.9	21.4	20.2	22.7	24.5
Copper	9.3	9.6	10.3	11.4	13.3	12.8	12.4	13.6	12.7	12.6
Nickel	11.9	11.2	11.6	9.5	10.6	11.1	10.2	14.5	13.4	10.9
Iron ore	10.3	12.0	11.1	10.8	10.7	11.2	9.6	10.3	9.3	8.1
Zinc	4.0	5.7	6.7	7.3	7.3	6.9	7.8	7.0	7.0	7.9
Natural gas	4.1	4.3	4.3	4.4	4.5	4.8	5.5	5.5	5.7	6.1
Asbestos	4.5	4.3	3.9	4.1	3.7	4.0	4.1	3.6	3.4	3.4
Cement	3.9	3.8	3.8	3.9	3.3	3.1	3.4	2.7	3.2	3.3
Sand and gravel	4.1	3.7	3.6	3.8	3.3	2.7	2.6	2.3	2.6	2.4
Coal	2.4	2.2	2.1	2.1	1.3	1.1	1.1	1.5	2.0	2.3
Potash (K_2O)	0.7	0.9	1.5	1.6	1.5	1.8	1.5	1.9	2.3	2.2
Gold	5.0	4.3	3.6	3.1	2.5	2.1	2.0	1.5	1.3	1.9
Lead	1.5	1.6	2.4	2.3	2.0	1.9	2.0	2.2	1.8	1.8
Stone	2.6	2.5	2.6	2.7	2.3	2.0	1.9	1.5	1.6	1.5
Silver	1.4	1.2	1.2	1.2	1.4	2.2	1.8	1.4	1.2	1.2
Clay products	1.3	1.2	1.2	1.1	1.0	1.0	1.1	0.7	0.8	0.8
Salt	0.7	0.7	0.6	0.6	0.6	0.7	0.6	0.6	0.7	0.7
Titanium dioxide	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.7	0.6
Iron remelt	0.3	0.6	0.5	0.4	0.4	0.5	0.6	0.6	0.5	0.6
Molybdenum	0.04	0.06	0.5	0.9	0.9	0.8	1.1	1.0	0.6	0.5
Platinum metals	0.7	0.8	0.9	0.8	0.8	0.9	0.7	0.8	0.7	0.5
Lime	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
Sulphur, elemental	0.4	0.6	0.7	1.0	1.6	1.7	1.3	0.5	0.4	0.3
Gypsum	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3
Other minerals	8.5	7.3	6.1	5.8	6.0	5.5	6.0	4.9	4.7	5.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[p]Prelinimary.

Table 6. Canada, value of mineral production by provinces, 1963-1972

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972p
					($ millions)					
Alberta	644	709	762	849	974	1,092	1,205	1,396r	1,641	1,958
Ontario	874	904	994	958	1,195	1,356	1,223	1,593r	1,554	1,542
Quebec	541	685	716	771	741	725	717	803r	770	779
British Columbia	260	269	280	331	380	389	434	490	544	673
Saskatchewan	274	293	329	349	362	357	345	379	409	421
Manitoba	170	174	182	179	185	210	246	332	330	312
Newfoundland	138	182	208	244	266	310	257	353	343	304
Northwest Territories	15	18	77	111	118	116	119	105r	116	133
New Brunswick	29	49	83	90	90	88	95	134	107	132
Yukon	14	15	13	12	15	21	35	77	93	108
Nova Scotia	67	66	71	86	53	57	59	59r	60	54
Prince Edward Island	1	1	–	1	2	1	1	1	1	1
Total	3,027	3,365	3,715	3,981	4,381	4,722	4,736	5,722	5,968	6,417

pPreliminary; rRevised; – Nil.

Table 7. Canada, percentage contribution of provinces of total value to mineral production, 1963-1972.

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972p
Alberta	21.3	21.1	20.5	21.3	22.2	23.1	25.4	24.4	27.5	30.5
Ontario	28.9	26.9	26.8	24.1	27.3	28.7	25.8	27.8	26.0	24.0
Quebec	17.9	20.3	19.3	19.4	16.9	15.4	15.2	14.0	12.9	12.1
British Columbia	8.6	8.0	7.5	8.3	8.7	8.2	9.2	8.6	9.1	10.5
Saskatchewan	9.0	8.7	8.9	8.7	8.3	7.6	7.3	6.6	6.9	6.6
Manitoba	5.6	5.2	4.9	4.5	4.2	4.4	5.2	5.8	5.5	4.9
Newfoundland	4.6	5.4	5.6	6.1	6.1	6.6	5.4	6.2	5.8	4.7
Northwest Territories	0.5	0.5	2.1	2.8	2.7	2.4	2.5	2.4	1.9	2.1
New Brunswick	0.9	1.4	2.2	2.3	2.1	1.9	2.0	1.8	1.8	2.1
Yukon	0.5	0.5	0.3	0.3	0.3	0.5	0.7	1.4	1.6	1.7
Nova Scotia	2.2	2.0	1.9	2.2	1.2	1.2	1.3	1.0	1.0	0.8
Prince Edward Island	0.03	0.02	0.02	0.02	0.04	0.02	0.02	0.02	0.02	0.02
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

pPreliminary.

Table 8. Canada's world role as a producer of certain

	Year	World Production
Nickel (mine production)	1971 st % of world total	634,337
Zinc (mine production)	1971 st % of world total	5,858,358
Asbestos	1971 st % of world total	3,947,913
Silver	1971 000 troy oz % of world total	294,783
Potash K_2O (equivalent)	1971 000 st % of world total	22,247
Molybdenum (excludes communist countries)	1971 st % of world total	83,682
Elemental sulphur	1971 000 st % of world total	20,855
Gypsum	1971 000 st % of world total	58,466
Titanium concentrate (ilmenite)	1971 st % of world total	3,720,907
Aluminum (primary metal)	1971 st % of world total	11,861,800
Platinum group metals (mine production)	1970 troy oz % of world total	4,237,150
Gold (mine production)	1971 troy oz % of world total	46,523,539
Lead (mine production)	1971 st % of world total	3,761,668
Uranium (U_3O_8 concentrates)	1971 st % of world total	24,679
Cadmium (smelter production)	1971 000 pounds % of world total	36,713
Copper (mine production)	1971 st % of world total	6,918,249
Iron ore	1971 000 long tons % of world total	755,432

important minerals, 1971

Rank of Six Leading Countries with % of World Total					
1	2	3	4	5	6
Canada 294,341 46.4	U.S.S.R. 115,000 18.1	New Caledonia 112,727 17.8	Australia 40,274 6.3	Cuba 35,000 5.5	U.S.A. 15,500 2.4
Canada 1,249,734 21.3	U.S.S.R. 630,000 10.8	Australia 498,000 8.5	U.S.A. 491,419 8.4	Peru 341,713 5.8	Japan 324,538 5.5
Canada 1,634,579 41.4	U.S.S.R. 1,270,000 32.2	Rep. S. Africa 351,963 8.9	China 175,000 4.4	Italy 131,692 3.3	U.S.A. 130,882 3.3
Canada 46,024 15.6	U.S.A. 41,564 14.1	U.S.S.R. 39,000 13.2	Peru 38,398 13.0	Mexico 36,657 12.4	Australia 21,615 7.3
U.S.S.R. 5,897 26.5	**Canada** 4,000 18.0	West Germany 3,213 14.4	East Germany 2,700 12.1	U.S.A. 2,587 11.6	France 2,100 9.4
U.S.A. 54,796 65.5	**Canada** 11,332 13.5	U.S.S.R. 8,800 10.5	Chile 6,945 8.3	Peru 891 1.1	Norway 397 0.5
U.S.A. 8,611 41.3	**Canada** 3,149 15.1	Poland 2,778 13.3	France 1,778 8.5	U.S.S.R. 1,673 8.0	Mexico 1,247 6.0
U.S.A. 10,418 17.8	**Canada** 6,702 11.5	France 5,634 9.6	U.S.S.R. 5,200 8.9	Spain 4,630 7.9	U.K. 4,600 7.9
Australia 898,206 24.1	**Canada** 854,600 23.0	Norway 707,244 19.0	U.S.A. 683,014 18.4	Malaysia 171,941 4.6	Finland 153,772 4.1
U.S.A. 3,925,224 33.1	U.S.S.R. 1,900,000 16.0	**Canada** 1,104,644 9.3	Japan 984,600 8.3	Norway 582,710 4.9	Germany 471,234 4.0
U.S.S.R. 2,200,000 51.9	Rep. S. Africa 1,500,000 35.4	**Canada** 482,428 11.4	Columbia 26,358 0.6	U.S.A. 17,385 0.4	Japan 7,906 0.2
Rep. S. Africa 31,388,632 67.5	U.S.S.R. 6,700,000 14.4	**Canada** 2,260,730 4.9	U.S.A. 1,495,108 3.2	Ghana 697,517 1.5	Australia 670,136 1.4
U.S.S.R. 595,000 15.8	U.S.A. 573,377 15.2	**Canada** 433,465 11.5	Australia 425,592 11.3	Mexico 172,898 4.6	Peru 169,754 4.5
U.S.A. 12,907 52.3	Rep. S. Africa 4,189 17.0	**Canada** 4,107 16.6	France 1,677 6.8	Gabon 601 2.4	Niger 558 2.3
U.S.A. 7,930 21.6	Japan 5,700 15.5	U.S.S.R. 5,300 14.4	**Canada** 4,064 11.1	West Germany 2,220 6.0	Belgium 1,870 5.1
U.S.A. 1,533,100 22.2	U.S.S.R. 1,010,000 14.6	Chile 779,900 11.3	Zambia 717,597 10.4	**Canada** 721,430 10.4	Zaire 447,349 6.5
U.S.S.R. 200,385 26.5	U.S.A. 82,298 10.9	Australia 56,690 7.5	France 55,588 7.4	China 43,305 5.7	**Canada** 42,279 5.6

Table 9. Canada, census value added, commodity producing industries, 1965-1970

	($ millions)					
	1965	1966	1967	1968	1969	1970
Primary industries						
Agriculture	2,635	3,298	2,693	2,870r	3,032	2,840
Forestry	528r	596r	615r	644r	734	683
Fishing	160	176	164	186	184	205
Trapping	12	14	10	12	16	13
Mining*	2,476	2,613	2,918	3,176	3,342	3,851
Electric power	1,037	1,132	1,234	1,360	1,511	1,705
Total	6,848r	7,829r	7,634r	8,248r	8,819	9,297
Secondary industries						
Manufacturing	14,928	16,352	17,006	18,332r	20,134	20,048
Construction	3,987	4,844	5,148	5,269	5,794	6,143
Total	18,915	21,196	22,154	23,601	25,928	26,191
Grand Total	25,763r	29,025r	29,788r	31,849r	34,747	35,488

*Excludes Cement, Lime and Clay and Clay Products (from domestic clays) manufacture. These industries in the above tables are included under Manufacturing.

pPreliminary; rRevised.

Table 10. Canada, census value added, mining and mineral manufacturing industries, 1966-1970

	($000)				
	1966	1967	1968	1969	1970p
Mining					
Metallic					
Placer gold	1,339	257	264	155	120
Gold quartz	93,028	85,352	78,032	74,993	63,902
Copper-gold-silver	277,015	357,488	377,800	465,309	432,678
Silver-cobalt	5,715	6,870	7,645	6,088	4,184
Silver-lead-zinc	158,242	138,912	150,565	171,239	171,603
Nickel-copper	314,102	377,487	437,372	386,383	634,644
Iron	250,393	289,595	339,402	315,378	424,098
Misc. metal mines	78,266	78,437	72,306	104,433	101,824
Total	1,178,100	1,334,398	1,463,386	1,523,978	1,833,053
Industrial minerals					
Asbestos	134,694	136,918	143,591	157,855	164,037
Feldspar, quartz and nepheline	6,217	6,784	7,368	9,065	8,939
Gypsum	7,553	7,968	9,277	11,496	10,756
Peat	6,428	7,898	8,857	8,066	9,432
Salt	17,800	21,087	23,484	22,238	28,124
Sand and gravel	38,690	37,182	40,286	44,329	42,059
Stone	48,085	43,428	44,339	45,153	47,165
Talc and soapstone	748	640	824	785	784
Misc. nonmetals	61,430	64,268	60,450	62,005	92,451
Total	321,645	326,173	338,476	360,992	403,747
Fuels					
Coal	62,722	73,280	66,088	64,321	74,035
Petroleum and natural gas	1,050,424	1,183,818	1,307,995	1,392,994	1,540,581
Total	1,113,146	1,257,098	1,374,083	1,457,315	1,614,616
Total mining industry	2,612,891	2,917,669	3,175,945	3,342,285	3,851,416
Mineral manufacturing					
Primary metal industries					
Iron and steel mills	648,228	617,092	684,684	708,727	835,956
Steel pipe and tube mills	60,996	56,820	73,844	75,525	76,558
Iron foundries	117,780	108,944	106,610	123,331	119,721
Smelting and refining	416,058	448,124	477,763	513,806	552,540
Aluminum rolling, casting and extruding	41,499	58,410	66,496	82,837	80,163
Copper and alloy rolling, casting and extruding	59,903	51,968	59,105	61,054	52,319
Metal rolling, casting and extruding, n.e.s.	42,739	42,251	46,365	55,867	51,831
Total	1,387,203	1,383,609	1,514,867	1,621,147	1,769,088
Nonmetallic mineral products industries					
Cement manufacturers	111,048	100,496	107,088	117,521	115,175
Lime manufacturers	8,825	7,769	8,573	10,368	11,248
Gypsum products manufacturers	25,036	27,460	32,079	36,877	31,874
Concrete products manufacturers	118,548	116,742	122,789	126,965	125,170
Ready-mix concrete manufacturers	107,035r	92,273	106,314	109,951	108,467
Clay products (domestic clay)	30,494	30,906	33,996	37,270	32,553

(Continued on page 530)

Table 10. (concl'd)

	($000)				
	1966	1967	1968	1969	1970p
Clay products (imported clay)	23,814	23,195	24,652	22,399	21,947
Refractories manufacturers	14,895	16,132	16,924	19,759	23,212
Stone products manufacturers	7,080	6,435	6,278	6,630	5,960
Mineral wool manufacturers	18,959	20,540	21,808	24,748	24,692
Asbestos products manufacturers	29,260	23,811	29,359	31,135	31,600
Glass manufacturers	63,651	71,631	93,692	100,230	104,955
Glass products manufacturers	37,471	40,175	43,396	50,784	50,005
Abrasives manufacturers	31,020	28,830	29,198	33,228	31,037
Other nonmetallic mineral products industries	8,487	8,914	9,895	11,074	11,415
Total	635,623	615,309	686,041	738,939	729,310
Petroleum and coal products industries					
Petroleum refining	253,291	270,086	307,298	293,416	331,965
Manufacturers of lubricating oils and greases	14,645	14,338	13,635	15,486	15,908
Other petroleum and coal products industries	8,532	8,367	8,484	8,266	8,355
Total	276,468	292,791	329,417	317,168	356,228
Total mineral manufacturing	2,299,294	2,291,709	2,530,325	2,677,254	2,854,626
Total mining and mineral manufacturing	4,912,185	5,209,378	5,706,270	6,019,539	6,706,042

pPreliminary; n.e.s. Not elsewhere specified.

Table 11. Canada, indexes of physical volume of total industrial production, mining and mineral manufacturing, 1957-72 (1961 = 100)

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969ʳ	1970ʳ	1971	1972ᵖ
Total industrial production	87.2	86.7	94.2	96.2	100.0	108.3	115.2	126.6	137.0	146.0	150.8	161.9ʳ	172.6	175.3	184.2	196.8
Total mining	84.6	86.0	97.3	97.4	100.0	106.2	112.1	126.0	131.9	134.2	142.1	152.4	153.5	175.3	182.9	191.8
Metals																
All metals	85.5	95.5	110.0	107.3	100.0	102.2	104.1	120.2	122.8	121.1	129.3	135.7ʳ	127.4	152.1	153.3	145.0
Placer gold and gold-quartz mines	100.0	104.1	102.2	104.4	100.0	95.1	91.4	90.1	87.4	82.2	73.6	66.8	64.9	57.7	55.5	50.2
Iron mines	97.4	70.7	105.2	103.6	100.0	139.3	170.4	208.6	224.8	241.5	260.7	313.8ʳ	274.8	347.0	338.7	276.3
Miscellaneous metal mines, n.e.s.	..	..	..	..	100.0	97.5ʳ	95.7ʳ	111.4ʳ	112.7ʳ	108.6ʳ	117.9ʳ	119.2ʳ	114.7	137.2	140.5	140.3
Fuels																
All fuels	83.1	76.5	84.1	87.1	100.0	114.3	123.0	133.0	142.0	152.4	166.1	181.1ʳ	199.0	229.6	249.0	295.7
Coal	131.1	113.8	103.8	107.0	100.0	97.9	104.5	109.8	111.9	103.7	103.1	100.2ʳ	99.6	128.2	149.0	207.4
Crude petroleum and natural gas	..	..	..	..	100.0	117.3	126.3	137.2	147.4	161.2	177.5	195.7	217.0	247.9	267.1	311.6
Nonmetals																
All nonmetals	84.8	80.3	92.0	91.5	100.0	108.7	121.4	139.2	151.5	164.2	173.6	191.9ʳ	202.3	211.0	219.6	220.7
Asbestos	83.8	79.8	86.4	90.3	100.0	103.2	109.0	121.9	118.2	127.7	125.6	135.9ʳ	133.0	146.5	146.3	141.4
Mineral Manufacturing																
Primary metals	..	..	..	..	100.0	105.5	114.3	128.4	140.4	146.1	141.1	158.2ʳ	164.8	171.0	172.6	180.3
Nonmetallic mineral products	88.4	91.8	99.0	95.8	100.0	115.0	116.7	128.0	139.3	144.9	135.4	147.2	154.3	145.9	157.4	168.0
Petroleum and coal products	81.5	82.3	90.2	94.1	100.0	108.7	117.2	118.5	124.4	129.1	130.5	144.3	150.2	153.2	165.2	182.4

ᵖPreliminary; . . Not available; ʳRevised; n.e.s. Not elsewhere specified.

Table 12. Indexes of real domestic product by industries, 1963-1972 (1961 = 100)

	1963	1964	1965	1966	1967	1968	1969[r]	1970[r]	1971	1972[p]
Real domestic product, all industries	112.7	120.4	129.0	138.0	142.4	152.5[r]	161.6	165.6	175.0	184.3
Agriculture	136.9	123.9	127.6	145.9	118.6	126.0	133.3	131.4	152.7	137.6
Forestry	108.3	119.2	122.5	132.7	130.3	131.2	139.5	136.8	135.0	133.8
Fishing and trapping	106.4	108.9	106.6	118.2	112.1	127.1	112.8	115.5	107.9	95.8
Mining (including milling) quarries and oil wells	112.1	126.0	131.9	134.2	142.1	152.4	153.5	175.3	182.9	191.8
Electric power, gas and water utilities	111.6	120.8	129.9	141.4	151.2	162.8	177.7	194.3	207.6	228.9
Manufacturing	116.2	127.4	138.8	148.7	152.3	163.6[r]	175.4	173.0	181.7	193.9
Construction	107.1	117.4	131.6	141.7	141.2	147.4	152.1	150.6	165.6	166.5
Transportation, storage and communication	111.1	120.3	127.6	138.0	145.3	154.7[r]	165.5	174.0	182.7	195.9
Trade	111.2	119.5	129.4	137.6	144.7	150.6	158.3	160.0	170.6	182.6
Community, business and personal service	110.9	119.0	128.8	140.4	150.4	160.5[r]	172.0	179.4	187.0	194.8
Finance, insurance and real estate	110.5	115.0	120.8	125.6	131.4	152.8[r]	162.1	170.0	179.3	191.2
Public administration and defence	104.0	106.3	108.3	112.2	118.2	120.1[r]	122.7	127.0	132.4	138.9

[p]Preliminary.
[r]Revised.

Table 13. Canada, exports of crude minerals and fabricated mineral products, by main groups, 1968-72

	1968	1969	1970	1971	1972
			($ millions)		
Ferrous					
Crude material	458.3	363.5	508.9	431.8	371.8
Fabricated material	384.9	352.9	487.3	463.6	485.9
Total	843.2	716.4	996.2	895.4	857.7
Nonferrous					
Crude material	803.9	775.2	993.8	954.8	1,014.1
Fabricated material*	1,338.6r	1,286.2	1,689.7	1,389.7	1,388.9
Total	2,142.5r	2,061.4	2,683.5	2,344.5	2,403.0
Nonmetals					
Crude material	416.8r	427.3r	453.2	456.9	475.5
Fabricated material	70.0r	87.9r	99.8	100.6	133.2
Total	486.8r	515.2	553.0	557.5	608.7
Mineral fuels					
Crude material	621.2	711.7	884.6	1,124.6	1,420.9
Fabricated material	50.4	58.9	85.1	117.0	209.5
Total	671.6	770.6	969.7	1,241.6	1,630.4
Total minerals and products					
Crude material	2,300.2r	2,277.7r	2,840.5	2,968.1	3,282.3
Fabricated material	1,843.9r	1,785.9r	2,361.9	2,070.9	2,217.5
Total	4,144.1r	4,063.6	5,202.4	5,039.0	5,499.8

*Includes gold, refined and unrefined.
rRevised.

Table 14. Canada, value of imports of crude minerals and fabricated mineral products, by main groups, 1968-1972

	1968	1969	1970	1971	1972
			($ millions)		
Ferrous					
Crude material	48.7	47.5	54.4	50.9	53.1
Fabricated material	537.7[r]	723.6	718.4	805.0	850.3
Total	586.4[r]	771.1	772.8	855.9	903.4
Nonferrous*					
Crude material	172.5	145.7	188.9	192.0	182.6
Fabricated material	298.2	328.2	277.5	301.4	371.6
Total	470.7	473.9	466.4	493.4	554.2
Nonmetals					
Crude materials	64.1[r]	63.8	63.7	73.1	71.3
Fabricated materials	141.2	165.6	165.9	180.3	206.2
Total	205.3[r]	229.4	229.6	253.4	277.5
Mineral fuels					
Crude material	568.8	493.6	571.4	700.0[r]	868.9
Fabricated material	216.0	223.5	205.7	213.4[r]	209.6
Total	784.8	717.1	777.1	913.4[r]	1,078.5
Total minerals and products					
Crude material	854.1[r]	750.6	878.4	1,016.0[r]	1,175.9
Fabricated material	1,193.1[r]	1,440.9	1,367.5[r]	1,500.1[r]	1,637.7
Total	2,047.2[r]	2,191.5	2,245.9[r]	2,516.1[r]	2,813.6

*Includes gold, refined and unrefined.
[r]Revised.

Table 15. Canada, value of exports of crude minerals and fabricated mineral products in relation to total export trade, 1968-72

	1968		1969		1970		1971		1972	
	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total
Crude material	2,300.2r	17.3	2,277.7r	15.7	2,840.5	17.2	2,968.1	17.0	3,282.3	16.8
Fabricated material	1,843.9r	13.9	1,785.9r	12.3	2,361.9	14.3	2,070.9	11.9	2,217.5	11.4
Total	4,144.1r	31.2	4,063.6r	28.0	5,202.4	31.5	5,039.0	28.9	5,499.8	28.2
Total exports* all products	13,269.9r	100.0	14,498.2r	100.0	16,491.1r	100.0	17,424.2r	100.0	19,500.1	100.0

*Includes gold, refined and unrefined.
rRevised.

Table 16. Canada, value of imports of crude minerals and fabricated mineral products in relation to total import trade, 1968-72

	1968		1969		1970		1971		1972	
	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total
Crude material	854.1r	6.9	750.6	5.3	878.4	6.3	1,016.0r	6.5	1,175.9	6.3
Fabricated material	1,193.1r	9.7	1,440.9	10.2	1,367.5	9.8	1,500.1r	9.6	1,637.7	8.7
Total	2,047.2r	16.6	2,191.5	15.5	2,245.9	16.1	2,516.1r	16.1	2,813.6	15.0
Total imports* all products	12,366.7r	100.0	14,130.3	100.0	13,939.4r	100.0	15,606.6	100.0	18,735.3	100.0

*Includes gold, refined and unrefined.
rRevised.

Table 17. Canada, value of exports of crude minerals and fabricated mineral products, by main groups and destination, 1972

	Britain	United States	Other Countries	Total
		($ millions)		
Ferrous materials and products	60.8	626.9	170.0	857.7
Nonferrous* materials and products	446.0	1,027.9	929.1	2,403.0
Nonmetallic mineral materials and products	22.7	361.4	224.6	608.7
Mineral fuels, materials and products	2.6	1,504.8	123.0	1,630.4
Total	532.1	3,521.0	1,446.7	5,499.8
Percentage	9.7	64.0	26.3	100.0

*Includes gold, refined and unrefined.

Table 18. Canada, value of imports of crude minerals and fabricated mineral products, by main groups of country of origin, 1972

	Britain	United States	Other Countries	Total
		($ millions)		
Ferrous materials and products	64.7	559.4	279.2	903.3
Nonferrous* materials and products	25.9	310.4	217.9	554.2
Nonmetallic mineral materials and products	13.8	189.5	74.3	277.6
Mineral fuels, material and products	6.9	259.3	812.3	1,078.5
Total	111.3	1,318.6	1,383.7	2,813.6
Percentage	3.9	46.9	49.2	100.0

*Includes gold, refined and unrefined.

Table 19. Canada, value of exports of crude minerals and fabricated mineral products, by commodity and destination, 1972

	U.S.A.	Britain	Other[1] E.F.T.A. Countries	E.E.C.[2] Countries	Japan	Other Countries	Total
				($ 000)			
Aluminum	246,860	43,472	4,592	21,595	32,465	54,873	403,857
Asbestos	86,834	16,479	8,166	42,035	13,439	68,225	235,178
Copper	202,103	122,908	38,965	72,051	195,653	32,057	663,737
Fuels	1,504,824	2,582	3,073	1,743	110,705	7,455	1,630,382
Iron ore	244,721	35,572	218	41,385	17,930	12,854	352,680
Lead	25,738	12,507	131	8,417	21,408	2,108	70,309
Molybdenum	531	10,901	1,123	36,997	8,049	2,165	59,766
Nickel	308,183	174,352	114,756	20,024	37,584	34,031	688,930
Primary ferrous metals	56,491	5,699	49	14,036	1,511	10,073	87,859
Uranium	23,040	16,456	–	–	–	–	39,496
Zinc	108,420	23,348	2,302	75,732	27,832	19,241	256,875
All other minerals[3]	713,267	67,878	6,449	50,945	32,831	139,378	1,010,748
Total	3,521,012	532,154	179,824	384,960	499,407	382,460	5,499,817

[1] Other European Free Trade Association countries: Austria, Denmark, Norway, Portugal, Sweden and Switzerland;
[2] European Economic Community (Common Market) countries: Belgium, France, Italy, Luxembourg, Netherlands and West Germany;
[3] Includes gold, refined and unrefined.
–Nil.

Table 20. Canada, reported consumption of minerals

		1969			
	Unit of Measure	Consumption	Production	Consumption as a % of Production	Consumption
Metals					
Aluminum	st	269,027	1,078,717	24.9	275,743
Antimony	lb	1,305,742	820,122	159.2	1,142,009
Bismuth	lb	33,800	579,059	5.8	24,548
Cadmium	lb	132,136	5,213,054	2.5	124,959
Chromium (chromite)	st	68,484	–	. .	61,963
Cobalt	lb	393,658	3,255,623	12.1	327,030
Copper	st	226,281[a]	573,246	39.5	237,916[a,r]
Lead	st	105,915[b]	318,632	33.2	93,437[b,r]
Magnesium	st	5,672	10,637	53.3	4,937
Manganese ore	st	168,485	–	. .	169,586
Mercury	lb	308,814	. .	. .	340,558
Molybdenum (Mo content)	lb	1,808,772	29,651,261	6.1	2,286,061
Nickel	st	12,094	213,612	5.7	11,794
Selenium	lb	15,572	599,415	2.6	15,730
Silver	oz	5,747,068	43,530,941	13.2	6,034,028
Tellurium	lb	3,532	62,048	5.7	880
Tin	lt	4,280	129	3,317.8	4,482
Tungsten (W content)	lb	1,050,824	4,063,488	25.9	984,777
Zinc	st	121,420[b]	1,207,625	10.1	108,364[b]
Nonmetals					
Barite	st	41,000[r]	143,320	28.6	55,200[r]
Feldspar	st	7,635	12,385	61.6	7,540[r]
Fluorspar	st	200,827	131,600*	152.6	212,949
Mica	lb	5,368,000	–	. .	5,746,000
Nepheline syenite	st	78,314	500,571	15.6	83,360
Phosphate rock	st	1,822,069	–	. .	1,896,684
Potash K_2O)[c]	st	185,527	3,085,995	6.0	192,479[r]
Sodium sulphate	st	437,055	518,299	84.3	406,812[r]
Sulphur, elemental	st	770,846	2,973,506	25.9	841,782[r]
Talc, etc.	st	38,093	75,850	50.2	35,432
Fuels					
Coal	st	26,455,330	10,671,879	247.9	29,757,279
Natural gas	mcf	843,164,967[d]	1,977,838,205	42.6	917,440,879[d]
Petroleum, crude	bbl	432,513,825[e]	410,989,930	105.2	467,306,197[e]

Note: Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. Production of metals, in most cases, refers to production in all forms, and includes the recoverable metal content of ores, concentrates, matte, etc., and the metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.

[a]Producers, domestic shipments of refined metal; [b]Includes primary and secondary refined metal; [c]Production and consumption for year ended June 30; [d]Domestic sales; [e]Refinery receipts.

[p]Preliminary; [r]Revised; *Estimates.

–Nil; . .Not available or not applicable.

and relation to production, 1969-72

1970		1971			1972[p]		
Production	Consumption as a % of Production	Consumption	Production	Consumption as a % of Production	Consumption	Production	Consumption as a % of Production
1,061,020[r]	26.0	322,524	1,104,644	29.2	267,696[a]	1,012,674	26.4
726,474	157.2	1,461,763	323,525	451.8	1,999,155	470,000	425.4
590,340	4.2	35,876	271,196	13.2	34,575	256,000	13.5
4,307,953	2.9	117,395	4,063,805	2.9	114,403	3,924,000	2.9
–	..	61,313	–	..	62,712	–	..
4,561,213	7.2	220,994	4,323,318	5.1	281,081	4,151,000	6.8
672,717	35.4	221,053[a]	721,430	30.6	228,906[a]	801,690	28.6
389,185	24.0	94,617[b]	405,510	23.3	..	371,332	..
10,353	47.7	6,276	7,234	86.8	5,922	5,844	101.3
–	..	174,761	–	..	183,175	–	..
..	..	193,968	..	..	114,636	..	..
33,771,716	6.8	1,814,586	22,662,732	8.0	2,706,374	34,844,000	10.9
305,881	3.9	8,583	294,341	2.9	10,093	258,087	3.9
663,336	2.4	15,686	718,440	2.2	20,677	655,000	3.2
44,250,804	13.6	7,050,956	46,023,570	15.3	8,401,383	48,488,000	17.3
58,333	1.5	1,178	24,488	4.8	1,419	48,000	3.0
118	3,798.3	3,911	142	2,754.2	4,590	161	2,850.9
3,726,800	26.4	639,765	4,624,208	13.8	1,163,802	4,956,000	23.5
1,251,911	8.7	114,334[b]	1,249,734	9.1	137,699[a]	1,323,646	10.4
147,251	37.5	58,200	120,765	48.2	74,700	73,000	102.3
10,656	70.8	8,856	10,774	82.2	..	10,000	..
136,800*	155.7	197,600	85,000*	232.5	..	160,000*	..
–	..	8,354,000	–	..	..	–	..
486,667	17.1	73,691	517,190	14.2	..	560,000	..
–	..	2,031,289	–	..	..	–	..
3,930,662	4.9	203,193	3,422,436	5.9	206,908	4,151,105	5.0
490,547	82.9	383,880	481,919	79.7	..	503,000	..
3,548,310	23.7	804,708	3,149,280	25.6	800,000*	3,271,000	24.5
72,055	49.2	38,742	65,562	59.1	..	80,000	
16,604,164	179.2	28,466,201	18,432,199	154.4	31,000,000*	20,709,718	149.7
2,277,108,791	40.3	1,001,328,624[d]	2,499,023,600	40.1	1,145,797,145[d]	2,913,047,178	39.3
461,180,059	101.3	507,463,990[e]	492,739,049	103.0	562,041,539[e]	562,452,519	99.9

Table 21. Canada, apparent consumption* of some minerals

		1969			
Mineral	Unit of Measure	Apparent Consumption	Production	Consumption as a % of Production	Apparent Consumption
Asbestos	st	53,855	1,611,168	3.3	105,045
Cement	st	7,669,220	8,250,032	93.0	7,476,585
Gypsum	st	1,584,263	6,373,648	24.9	1,504,099
Iron Ore	lt	10,116,993	35,762,745	28.3	10,107,938
Lime	st	1,480,928	1,634,862	90.6	1,481,125
Quartz (silica)	st	3,504,114	2,300,374	152.3	4,469,629
Salt	st	4,338,000[e]	4,657,765	93.1	4,739,000[e]

* Apparent consumption – production plus imports less exports.
**Production – producers' shipments.
[e]Estimated.

and relation to production, 1969-72**

1970		1971			1972p		
Production	Consumption as a % of Production	Apparent Consumption	Production	Consumption as a % of Production	Apparent Consumption	Production	Consumption as a % of Production
1,661,644	6.3	68,755	1,634,579	4.2	99,905	1,692,000	5.9
7,945,915	94.1	8,234,823	9,066,795	90.8	8,799,294	10,010,000	87.9
6,318,523	23.8	1,772,909	6,702,100	26.5	2,041,410	7,942,000	25.7
46,708,946	21.6	10,016,147	42,278,733	23.7	11,939,554	39,027,000	30.6
1,647,954	89.9	1,340,961	1,598,254	83.9	1,338,543	1,606,000	83.4
3,238,037	138.0	3,873,498	2,553,884	151.7	3,931,276	2,700,000	145.6
5,358,896	88.4	5,312,000e	5,541,904	95.8	5,748,000	5,535,000	103.8

Table 22. Canada, domestic consumption of principal refined metals in relation to refinery production[a], 1963-72

	Unit of Measure or Percentage	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972[p]
Copper											
Domestic consumption[b]	st	169,750	202,225	224,684	262,557	219,680	250,104	226,281	237,916[r]	221,053	228,906
Production	st	380,075	407,942	434,133	433,004	499.846	524,474	449,232	543,727[r]	526,403	546,686
Consumption of production	%	44.7	49.6	51.8	60.6	43.9	47.7	50.4	43.8	42.0	41.9
Zinc											
Domestic consumption[c]	st	75,591[r]	91,052[r]	97,345[r]	110,481[r]	110,487[r]	118,581[r]	121,420[r]	108,364	114,334	137,699[b]
Production	st	284,021	337,734	358,498	382,605	405,136	426,728	466,357	455,471[r]	410,643	524,885
Consumption of production	%	26.6	27.0	27.2	28.9	27.3	27.8	26.0	23.8	27.8	26.2
Lead											
Domestic consumption[c]	st	77,958	82,736	90,168	96,683	93,953	94,660	105,915	93,437[r]	94,617	. .
Production	st	155,000	151,372	186,484	184,871	193,235	202,100	187,143	204,630	185,554	205,978
Consumption of production	%	50.3	54.7	48.4	52.3	48.6	46.8	56.6	45.7	51.0	. .
Aluminum											
Domestic consumption[c]	st	161,833	172,443	213,094	243,301	217,484	242,390	269,027	275,743	322,524	267,696[b]
Production	st	719,390	842,640	830,505	889,915	963,343	979,171	1,078,717	1,061,020	1,104,644	1,012,132[b]
Consumption of production	%	22.5	20.5	25.7	27.3	22.6	24.8	24.9	26.0	29.2	26.4

[a]Production of refined metal from all sources, including metal derived from secondary materials at primary refineries.
[b]Producers' domestic shipments, of refined metal.
[c]Consumption primary and secondary refined metal, reported by consumers.
[r]Revised; [p]Preliminary.
. . Not available.

Table 23. Annual averages of prices of main metals[1] 1968-72 (Cont'd)

	Unit of Measure	1968	1969	1970	1971	1972
Aluminum ingot, 99.5%	cents/lb	25.583	27.176	28.716	29.000	26.409
Antimony, RMM, fob Loredo, Texas	cents/lb	44.000	55.700	141.640	69.300	57.000
Bismuth, ton lots, delivered	$/lb	4.000	4.625	6.000	5.260	3.625
Cadmium	cents/lb	270.000	331.917	362.452	197.262	255.600
Calcium, ton lots crowns	$/lb	0.95	0.95	0.95	0.95	0.95
Chromium metal, 98.5%, 0.5%C	$/lb	0.96	0.97	1.15	1.15	1.30
Cobalt metal, 500 lb lots	$/lb	1.850	1.910	2.20	2.20	2.450
Columbium	$/lb	11-22	11-22	11-22	11-22	11-22
Copper, U.S. domestic, fob refinery	cents/lb	41.847[2]	47.534	57.700	51.433	50.617
Gold, Royal Canadian						
Mint buying price	$Cdn/t.oz	37.71	37.70	36.56	35.35	36.58
London free market[3]	$Cdn/t.oz	..	..	37.51	41.20	57.54
Iridium	$/t.oz	185-190	177-182	154-159	150-155	150-178
Iron ore, 51.5% Fe, lower lake ports						
Bessemer						
Mesabi	$/lt	10.70	10.69	10.55-10.95	11.25	11.32
Old Range	$/lt	10.95	10.95	10.95-11.20	11.51	11.57
Non-Bessemer						
Mesabi	$/lt	10.55	10.55	10.55-10.80	11.11	11.17
Old Range	$/lt	10.80	10.80	10.80-11.05	11.36	11.42
Lead, common, New York	cents/lb	13.212	14.895	15.619	13.800	15.029
Manganese	cents/lb	24.50	25.69	27.25	29.10	33.25
Magnesium, ingot	cents/lb	35.250	35.250	35.250	36.250	37.250
Mercury	$flask(76 lb)	535.555	505.043	407.769	292.413	218.279
Molybdenum metal	$/lb	3.69	3.82	4.00	4.00	4.00
Molybdenite, 95% MoS_2 contained MO	$/lb	1.62	1.68	1.73	1.72	1.72
Nickel, fob Port Colborne (duty free)	cents/lb	94.071	105.431	129.080	133.000	139.700
Osmium	$/t.oz	300-450	254-331	200-225	200-225	200-225
Palladium	$/t.oz	42.649	40.845	36.416	37.000	41.644
Platinum	$/t.oz	114.500	121.667	130.00	120.524	120.779
Rhenium	$/lb	..	..	..	1400	975-1400[4]
Rhodium	$/t.oz	245-250	235-240	211-217	198-208	195-200
Ruthenium	$/t.oz	55-60	50-55	50-55	50-55	50-55
Selenium	$/lb	4.50	5.31	8.25	9.00	9.00
Silver, New York	cents/t.oz	214.460	179.067	177.082	154.564	168.455
Tantalum	$/lb	40-52	40-52	36-50	35.38-49.04	36.50
Tellurium, 100 lb powder	$/lb	6.00	6.00	6.00	6.00	6.00
Tin, Straits, New York	cents/lb	148.151	164.347	174.205	167.348	177.474
Titanium metal, 500 lb lots, 99.3%	$/lb	1.32	1.32	1.32	1.32	1.32
Titanium ore (ilmenite) 54% TiO_2	$/st	20.50	20.50	20-21	20-21	22-24
Tungsten metal	$/st	2.75	2.75	4.50	4.50	4.50
Vanadium 90%, 100 lb lots	$/lb	3.45	3.45	..	..	..
Zinc, prime western East St. Louis	cents/lb	13.500	14.600	15.319	16.128	17.753

[1] These prices, except for gold are in United States currency, and are from Metals Week.
[2] Average last nine months because of price quote suspension January through March.
[3] Average of A.M. and P.M. fixings of the London Gold Market, converted to Canadian Dollars.
[4] This price became effective August 14, 1972.

. . Not available or applicable.

Table 24. Canada, wholesale price indexes of minerals and mineral products, 1969-72 (1935-39 = 100)

	1969	1970	1971	1972
Iron and products	285.8	305.1	316.4	325.0
Pig iron	285.8	304.2	313.5	317.2
Rolling mill products	275.8	291.7	306.7	315.9
Pipe and tubing	304.4	309.2	321.4	331.8
Wire	314.2	347.3	368.3	382.8
Scrap iron and steel	250.0	328.9	284.2	268.1
Tin plate and galvanized sheet	258.8	267.2	282.5	295.0
Nonferrous metal and products				
Total (including gold)	264.0	281.0	260.1	262.9
Total (excluding gold)	389.6	422.9	387.6	388.4
Copper and products	493.1	511.5	440.3	428.0
Lead and products	318.4	330.5	282.9	322.7
Silver	497.5	478.1	405.6	430.6
Tin	338.0	349.6	324.2	338.8
Zinc and products	333.8	349.2	365.9	419.1
Nonmetallic minerals and products	210.0	215.7	225.8	233.6
Clay and clay products	265.8	274.6	280.3	289.8
Pottery	280.8	304.9	313.9	351.2
Coke	288.4	347.4	413.4	..
Petroleum products	165.5	170.8	182.6	187.3
Asphalt	197.7	197.7	225.2	229.2
Asphalt shingles	123.7	135.0	144.0	138.1
Plaster	181.3	183.1	185.0	198.0
Lime	273.7	282.1	299.4	347.1
Cement	201.2	207.9	216.4	229.7
Sand and gravel	185.2	186.9	187.8	216.6
Crushed stone	171.9	177.4	180.2	186.5
Building stone	257.7	266.9	282.6	298.3
Asbestos	366.3	375.9	383.2	397.4
General wholesale price index (all products)	282.4	286.4	289.9	310.3

Table 25. Canada, general wholesale price index and wholesale price indexes of mineral and nonmineral products, 1948-1972 (1935-39 = 100)

	Mineral Products			Nonmineral Products					
	Iron Products	Nonferrous Metal Products	Nonmetallic Mineral Products	Vegetable Products	Animal Products	Textile Products	Wood Products	Chemical Products	General Wholesale Price Index
1948	161.4	146.9	150.8	185.7	236.7	216.3	238.3	152.2	193.4
1949	175.5	145.2	158.3	190.5	237.5	222.5	241.6	155.2	198.3
1950	183.6	159.5	164.8	202.0	251.3	246.7	258.3	157.8	211.2
1951	208.7	180.6	169.8	218.6	297.7	295.9	295.9	187.3	240.2
1952	219.0	172.9	173.9	210.3	248.2	251.5	291.0	180.1	226.0
1953	221.4	168.6	176.9	199.0	241.7	239.0	288.6	175.7	220.7
1954	213.4	167.5	177.0	196.8	236.0	231.1	286.8	176.4	217.0
1955	221.4	187.6	175.2	195.1	226.0	226.2	295.7	177.0	218.9
1956	239.8	199.2	180.8	197.3	227.7	230.2	303.7	180.1	225.6
1957	252.7	176.0	189.3	197.0	238.4	236.0	299.4	182.3	227.4
1958	252.6	167.3	188.5	198.1	250.7	229.0	298.5	183.0	227.8
1959	255.7	174.6	186.5	199.5	254.3	228.0	304.0	187.0	230.6
1960	256.2	177.8	185.6	203.0	247.6	229.8	303.8	188.2	230.9
1961	258.1	181.6	185.2	203.1	254.7	234.5	305.1	188.7	233.3
1962	256.2	192.1	189.1	211.6	262.5	241.2	315.9	190.5	240.0
1963	253.6	197.5	189.5	227.8	255.6	248.0	323.4	189.3	244.6
1964	256.4	205.9	190.9	223.3	250.8	248.4	330.9	191.2	245.4
1965	264.5	217.6	191.6	218.4	270.7	246.4	334.0	200.2	250.3
1966	268.0	229.9	193.7	225.9	296.2	251.5	337.8	207.1	259.5
1967	274.4	240.2	199.2	230.9	293.1	252.7	346.3	212.6	264.1
1968	276.8	250.8	206.0	230.8	294.6	256.5	367.9	213.7	269.9
1969	285.8	264.0	210.0	237.9	322.4	256.7	389.4	219.7	282.4
1970	305.1	281.0	215.7	238.4	326.0	257.0	377.5	225.7	286.4
1971	316.4	260.1	225.8	237.1	326.0	261.9	394.4	237.8	289.9
1972	325.9	262.9	233.6	249.2	371.8	278.3	436.0	245.5	310.3

Table 26. Canada, mineral products industries, selling price indexes, 1969-72 (Base Year, 1961 = 100)

	1969	1970	1971	1972
Iron and steel products industries				
Agriculture implements industry	118.5	122.1	125.5	130.2
Hardware, tool and cutlery manufacturers	121.0	126.5	130.9	137.1
Heating equipment manufacturers	107.6	111.1	113.5	116.8
Primary metal industries	129.0	136.9	132.3	134.7
Iron and steel mills	106.7	112.6	118.0	121.9
Steel pipe and tube mills	95.5	98.9	103.0	106.7
Iron foundries	122.0	127.7	131.4	136.3
Wire and wire products manufacturers	110.1	119.5	124.5	129.6
Nonferrous metal products industries				
Aluminum rolling, casting and extruding	107.2	109.7	109.8	109.4
Copper and alloy, rolling, casting and extruding	164.7	181.0	169.4	167.1
Jewellery and silverware manufacturers	144.0	148.5	145.5	159.1
Metal rolling, casting and extruding, n.e.s.	158.1	176.0	151.0	156.6
Nonmetallic metal products industries				
Abrasive manufacturers	110.3	112.2	110.9	111.3
Cement manufacturers	121.1	125.8	130.3	138.7
Clay products manufacturers from imported clay	115.5	116.9	121.2	124.0
Glass manufacturers	119.3	125.4	130.6	143.6
Lime manufacturers	124.4	129.1	138.3	149.4
Gypsum products manufacturers	117.0	119.4	119.5	127.1
Concrete products manufacturers	120.5	125.4	127.5	130.8
Clay products from domestic clay	118.3	121.1	124.6	129.8
Petroleum and coal products industries	100.1	103.1	113.9	115.7
Petroleum refining	99.7	102.8	113.7	115.4
Lubricating oils and grease	121.4	122.2	128.4	133.4
Manufacturers of mixed fertilizers	110.0	108.9	112.8	115.2

Note: Industry selling price indexes reflect wholesale price trends of products or groups of products sold by the industries listed.
n.e.s. – Not elsewhere specified.

Table 27. Canada, principal statistics of the mining industry, 1970

	Mining Activity								Total Actitivy		
		Production and Related Workers							Employees		
	Establishments		Man-Hours Paid	Wages	Cost of fuel and Electricity	Cost of Materials and Supplies	Value of production	Value Added		Salaries and Wages	Value Added
	Number	Number	000	$ 000	$ 000	$ 000	$ 000	$ 000	Number	$ 000	$ 000
Metals											
Placer gold	11	8	12	32	21	75	216	120	10	42	120
Gold quartz	30	5,982	12,493	36,203	5,444	26,015	95,361	63,902	7,175	45,609	64,070
Copper-gold-silver	47	11,826	24,907	90,980	15,964	246,104	694,745	432,678	15,550	124,998	442,058
Silver-cobalt	6	339	694	2,203	251	1,383	5,818	4,184	407	2,699	4,211
Silver-lead-zinc	24	4,987	10,704	39,235	8,873	136,800	317,276	171,603	6,696	56,135	172,153
Nickel-copper	8	16,691	35,107	149,303	11,085	393,311	1,039,040	634,644	20,703	197,179	636,667
Iron	17	7,609	16,416	74,031	37,621	134,190	595,909	424,098	11,336	114,459	424,469
Misc. metal mines	18	3,660	7,864	29,906	6,389	33,744	141,958	101,824	4,713	39,425	102,562
Total	161	51,102	108,197	421,893	85,648	971,622	2,890,323	1,833,053	66,590	580,546	1,846,310
Nonmetals											
Asbestos	12	6,186	14,427	49,488	12,386	41,767	218,190	164,037	7,664	63,236	163,370
Feldspar, quartz and nepheline syenite	14	358	775	2,181	674	2,241	11,854	8,939	453	2,927	8,880
Gypsum	13	563	1,273	3,401	721	2,778	14,254	10,756	671	4,282	10,686
Peat	62	1,071	2,203	4,215	550	3,707	13,689	9,432	1,195	5,079	9,163
Salt	9	867	1,836	6,207	1,498	6,653	36,275	28,124	1,318	9,805	28,380
Sand and gravel	158	1,782	4,142	11,815	3,241	7,421	52,721	42,059	2,322	16,784	42,895
Stone	134	2,483	5,790	15,523	4,233	16,683	68,081	47,165	3,023	19,712	47,261
Talc and soapstone	4	71	164	342	75	311	1,170	784	98	516	792
Misc. nonmetallics	22	2,864	6,188	21,173	10,631	20,439	123,521	92,451	3,751	29,580	94,305
Total	428	16,245	36,798	114,345	34,009	102,000	539,755	403,747	20,495	151,921	405,732
Fuels											
Coal	39	6,065	11,557	42,805	5,890	42,693	122,619	74,035	7,874	56,745	73,210
Petroleum and natural gas	1,008	3,796	8,283	35,041	20,502	51,141	1,612,224	1,540,581	14,970	152,845	1,551,637
Total	1,047	9,861	19,840	77,846	26,392	93,834	1,734,843	1,614,616	22,844	209,590	1,624,847
Total mining industry	1,636	77,208	164,835	614,084	146,049	1,167,456	5,164,921	3,851,416	109,929	942,057	3,876,889

Note: Total activity in this table and also in Tables 28, 29 and 30 includes sales and head offices.

Table 28. Canada, principal statistics of the mineral manufacturing industries, 1970

	Mineral Manufacturing Activity								Total Acitvity		
		Production and Related Workers							Employees		
	Estab-lish-ment		Man-Hours Paid	Wages	Cost of Fuel and Elec-tricity	Cost of Materials and Supplies	Value of Production	Value Added		Salaries and Wages	Value Added
	Number	Number	000	$ 000	$ 000	$ 000	$ 000	$ 000	Number	$ 000	$ 000
Primary metal industries											
Iron and steel mills	45	38,317	79,657	309,128	62,675	831,794	1,691,662	835,956	49,169	423,985	838,430
Steel pipe and tube mills	25	4,270	9,528	34,457	4,584	177,986	252,219	76,558	5,314	45,041	76,338
Iron foundries	116	9,065	19,349	63,648	6,107	85,246	212,290	119,721	10,663	79,320	121,671
Smelting and Refining	25	26,537	54,189	202,502	88,630	438,846	1,080,015	552,540	37,298	305,885	586,182
Aluminum Rolling, Casting and Extruding	65	4,557	9,703	31,538	3,806	158,438	241,851	80,163	6,297	48,587	79,718
Copper and Alloy Rolling Casting and Extruding	52	2,960	6,567	21,567	2,548	233,454	286,184	52,319	3,744	29,530	52,389
Metal Rolling, Casting and Extruding	79	3,133	6,564	17,939	2,340	99,607	154,329	51,831	4,060	26,159	54,150
Total Primary Metal Industries	407	88,839	185,557	680,779	170,690	2,025,371	3,918,550	1,769,088	116,545	958,507	1,808,878
Nonmetallic mineral products industries											
Cement manufacturers	26	2,520	5,527	20,785	23,743	28,008	165,604	115,175	3,887	34,085	114,410
Lime Manufacturers	13	525	1,105	3,282	4,706	4,259	20,165	11,248	660	4,433	11,501
Gypsum Products Manufacturers	16	1,066	2,290	7,448	2,412	19,499	54,177	31,874	1,752	13,523	33,626
Concrete Products Manufacturers	492	7,395	16,126	46,981	5,609	79,135	206,462	125,170	9,562	66,031	128,665
Ready Mix Concrete Manufacturers	317	5,436	12,205	38,840	7,694	149,668	266,315	108,467	7,340	55,045	116,696
Clay Products Manufacture (domestic)	72	2,427	5,237	14,609	5,643	8,834	45,193	32,553	2,958	19,163	32,853
Clay Products Manufacture (imported)	41	1,532	3,219	8,835	1,221	10,865	33,648	21,947	1,940	11,592	22,158
Refractories Manufacturers	18	728	1,579	4,921	1,369	17,895	42,270	23,212	1,259	9,529	24,346
Stone Products Manufacturers	86	447	935	2,197	218	3,572	9,529	5,960	611	3,367	6,006

Table 28. (concl'd)

	Mineral Manufacturing Activity								Total Activity		
		Production and Related Workers							Employees		
	Establishment		Man-Hours Paid	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added		Salaries and Wages	Value Added
	Number	Number	000	$ 000	$ 000	$ 000	$ 000	$ 000	Number	$ 000	$ 000
Glass Manufacturers	16	6,703	14,224	45,562	8,381	38,796	149,153	104,955	8,513	61,553	108,235
Glass Products Manufacturers	94	2,320	4,862	15,712	1,720	49,379	95,251	44,434	3,141	23,472	45,581
Mineral Wool Manufacturers	10	820	1,865	6,500	1,783	12,713	39,046	24,692	1,272	10,657	25,108
Asbestos Products Manufacturers	16	1,788	3,875	12,905	1,207	17,727	51,111	31,600	2,807	21,557	35,980
Abrasive Manufacturers	21	1,871	4,100	12,854	7,586	26,037	64,372	31,037	2,559	19,163	31,443
Other Nonmetallic Mineral Products Manufacturers	42	467	985	2,770	666	10,307	22,333	11,415	1,167	8,194	14,261
Total Nonmetallic Minerals	1,280	36,045	78,134	244,201	73,958	476,694	1,264,629	723,739	49,428	361,364	750,869
Petroleum and coal products industries											
Petroleum Refining Industry	40	6,077	13,533	60,500	18,181	1,418,328	1,758,940	331,965	14,725	153,598	333,057
Manufacturers of Lubricating Oils and Greases	17	237	514	1,839	232	23,011	39,632	15,908	423	3,555	17,743
Other Petroleum and Coal Products Industries	37	372	809	2,406	766	11,225	20,555	8,355	499	3,500	9,834
Total Petroleum and Coal Products Industries	94	6,686	14,856	64,745	19,179	1,452,564	1,819,127	356,228	15,647	160,653	360,634
Total Mineral Manufacturing Industries	1,781	131,570	278,547	989,725	263,827	3,954,629	7,002,306	2,849,055	181,620	1,480,524	2,920,381

Table 29. Canada, principal statistics of the mining industry*, 1965-1970

	Mineral Activity								Total Activity		
		Production and Related Workers							Employees		
	Establishments		Man-Hours Paid	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added		Salaries and Wages	Value Added
	Number	Number	000's	$000	$000	$000	$000	$000	Number	$000	$000
1965	1,467	75,046	162,542	396,731	96,393	650,139	3,222,441	2,475,910	100,820	582,101	2,514,269
1966	1,422	74,195	158,156	419,496	98,867	706,109	3,417,868	2,612,891	102,063	629,232	2,636,524
1967	1,478	74,230	159,182	465,489	107,563	806,577	3,831,808	2,917,669	102,678	700,678	2,943,224
1968	1,548	75,066	160,346	510,003	119,640	900,344	4,195,930	3,175,945	104,916	772,453	3,189,271
1969	1,686	71,368	151,072	513,708	126,999	931,354	4,400,637	3,342,285	102,088	804,839	3,355,312
1970	1,636	77,208	164,835	614,084	146,049	1,167,456	5,164,921	3,851,416	109,929	942,057	3,876,889

*Excludes cement manufacturing, lime manufacturers, clay and clay products (domestic clays). These industries are included in the Mineral Manufacturing Industries. Industry coverage is the same as in Tables 27, 31 and 32.

Table 30. Canada, principal statistics of the mineral manufacturing industries*, 1965-1970

	Mineral Manufacturing Activity								Total Activity		
		Production and Related Workers							Employees		
	Establishments		Man-Hours Paid	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added		Salaries Wages	Value Added
	Number	Number	000's	$000	$000	$000	$000	$000	Number	$000	$000
1965	1,842	128,514	279,340	710,220	194,895	2,995,152	5,322,623	2,178,365	163,837	951,414	2,238,542
1966	1,844	134,141	289,377	773,247	209,020	3,242,891	5,701,881	2,299,294	171,452	1,043,324	2,359,168
1967	1,797	131,090	282,982	801,636	210,519	3,241,716	5,692,956	2,291,709	169,441	1,095,187	2,342,764
1968	1,760	130,909	279,997	850,059	227,679	3,537,700	6,264,415	2,530,325	173,932	1,188,721	2,588,302
1969	1,802	128,263	275,947	890,911	232,861	3,689,337	6,581,618[r]	2,677,254[r]	167,487[r]	1,237,095	2,741,440[r]
1970	1,781	131,570	278,547	989,725	263,827	3,954,629	7,002,306	2,849,055	181,620	1,480,524	2,920,381

*Industry coverage in this table is the same as in Tables 28, 33 and 34.
[r]Revised.

Table 31. Canada, consumption of fuel and electricity in the mining industry[1], 1970

	Unit	Metals	Nonmetals	Fuels	Total
Coal and coke	000 st	67	44	...	111
	$000	1,121	434	3	1,558
Gasoline	000 gal.	5,101	8,153	1,648	14,902
	$000	1,991	3,062	506	5,559
Fuel oil, kerosene, coal oil	000 gal.	184,982	65,008	6,408	256,398
	$000	23,670	11,573	1,183	36,426
Liquified petroleum gas	000 gal.	4,402	424	587	5,413
	$000	773	118	64	955
Natural gas	000 Mcf	11,515	17,673	776	29,964
	$000	5,452	4,840	316	10,608
Other fuels[2]	$000	363	1	–	364
Total fuels	$000	33,370	20,028	2,072	55,470
Electricity purchased	Million kwh	7,995	1,468	1,540	11,003
	$000	52,257	13,981	24,320	90,558
Total value of fuels and electricity purchased	$000	85,627	34,009	26,392	146,028
Value of fuels and electricity of small establishments[3]	$000	21	–	–	21
Total value of fuels and electricity purchased, all reporting companies	$000	85,648	34,009	26,392	146,049
Electricity generated by industry for own use	Million kwh	365	161	–	526
Electricity generated by industry for sale	Million kwh	94	–	–	94

[1] Excludes cement and lime manufacturing and manufacture of clay products (from domestic clays). These industries are included under mineral manufacturing, Tables 33 and 34. Industry coverage is same as in Tables 27, 29 and 32.
[2] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.
[3] Value of fuels and electricity used by small establishments which have reported in total only without commodity detail.
. . . Less than 1,000 short tons.
– Nil.

Table 32. Canada, cost of fuel and electricity used in the mining industry[1], 1963-1970

	Units	1963	1964	1965	1966	1967	1968	1969	1970
Metals									
Fuel	$000	15,551	16,246	19,854	22,038	26,116	29,340	27,070	33,370
Electricity purchased	million kwh	3,711	4,371	5,533	5,511	6,300	7,020	7,073	7,995
	$000	25,456	27,810	34,517	35,248	38,342	42,340	46,002	52,257
Value of fuel and electricity used by small establishments[2]	$000	–	59	57	51	24	21	22	21
Total cost of fuel and electricity	$000	41,007	44,115	54,428	57,337	64,482	71,701	73,094	85,648
Electricity generated for own use and for sale	million kwh	465	447	483	473	510	466	476	459
Nonmetals									
Fuel	$000	11,928	12,279	14,623	15,410	16,180	18,448	19,793	20,029
Electricity purchased	million kwh	861	820	939	1,022	1,127	1,291	1,473	1,468
	$000	7,687	7,901	8,711	8,867	9,537	10,809	12,728	13,980
Value of fuel and electricity used by small establishments[2]	$000	–	703	740	735	548	342	401	–
Total cost of fuel and electricity	$000	19,615	20,883	24,074	25,012	26,265	29,599	32,922	34,009
Electricity generated for own use and for sale	million kwh	35	34	41	123	151	156	173[r]	161
Fuels									
Fuels	$000	6,387	765	827	720	690	678	739	2,072
Electricity purchased	million kwh	602	859	888	955	989	1,101	1,265	1,540
	$000	7,877	16,514	17,064	15,798	16,126	17,662	20,244	24,320
Value of fuel and electricity used by small establishments[2]	$000	–	–	–	–	–	–	–	–
Total cost of fuel and electricity	$000	14,264	17,279	17,891	16,518	16,816	18,340	20,983	26,392
Electricity generated for own use and for sale	million kwh	47	30	34	37	–	–	–	–
Total mining industry									
Fuel	$000	33,866	29,290	35,304	38,168	42,986	48,466	47,602	55,470
Electricity purchased	million kwh	5,174	6,050	7,360	7,488	8,416	9,412	9,811	11,003
	$000	41,020	52,225	60,292	59,913	64,005	70,811	78,974	90,558
Value of fuel and electricity used by small establishments[2]	$000	–	762	797	786	572	363	423	21
Total cost of fuel and electricity	$000	74,886	82,277	96,393	98,867	107,563	119,640	126,999	146,049
Electricity generated for own use and for sale	million kwh	547	511	558	633	661	622	649[r]	620

[1]See footnote Table 31. Industry coverage is the same as in Tables 27, 29 and 31. [2]Value of fuel and electricity used by small establishments which have reported in total only, without detail.
–Nil; [r]Revised.

Table 33. Canada, consumption fuel and electricity in the mineral manufacturing industry[1], 1970

	Unit	Primary Metals Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
Coal and coke	000 st	1,238	410	1	1,649
	$000	24,666	5,736	8	30,410
Gasoline	000 gal	4,095	15,597	430	20,122
	$000	1,409	5,970	166	7,545
Fuel oil, kerosene, coal oil	000 gal	321,587	169,587	3,339	494,513
	$000	27,873	16,220	372	44,465
Liquified petroleum gas	000 gal	10,457	1,730	8	12,195
	$000	1,336	399	2	1,737
Natural gas	000 Mcf	56,355	45,963	11,895	114,213
	$000	26,101	20,448	3,791	50,340
Other fuels	$000	1,649	678	410	2,737
Total fuels	$000	83,034	49,451	4,749	137,234
Electricity purchased	Million kwh	14,539	3,270	2,171	19,980
	$000	87,656	24,507	14,430	126,593
Total value, fuels and electricity purchased	$000	170,690	73,958	19,179	263,827
Value of purchased fuels and electricity of small establishments[2]	$000	–	–	–	–
Total value of fuels and electricity purchased, all reporting companies	$000	170,690	73,958	19,179	263,827

[1] Industry coverage is the same as in Tables 28, 30 and 34.
[2] Value of fuels and electricity used by small establishments which have reported in total only, without detail.
– Nil.

Table 34. Canada, cost of fuel and electricity used in the mineral manufacturing industries[1], 1963-70

Industries		1963	1964	1965	1966	1967	1968	1969	1970
Primary metals									
Fuel	$000	49,838	58,010	67,121	71,129	71,133	73,938	69,185	83,034
Electricity purchased	million kwh	8,672	11,150	11,326	12,531	13,118	14,363	15,370	14,539
	$000	42,070	47,920	52,388	56,774	60,624	68,834	73,114	87,656
Cost of fuel and electricity for small establishments[2]	$000	420	373	384	326	199	171	202	–
Total cost of fuel and electricity	$000	92,328	106,303	119,893	128,229	131,956	142,943	142,501	170,690
Nonmetallic mineral products									
Fuel	$000	35,693	38,453	42,925	45,479	44,055	45,237	47,310	49,451
Electricity purchased	million kwh	2,332	2,584	2,885	3,265	2,987	3,118	3,182	3,270
	$000	15,145	16,340	18,397	20,791	19,962	21,566	23,297	24,507
Cost of fuel and electricity for small establishments[2]	$000	869	893	1,104	1,122	852	1,165	1,231	–
Total cost of fuel and electricity	$000	51,707	55,686	62,426	67,392	64,869	67,968	71,838	73,958
Petroleum and coal products									
Fuel	$000	2,677	2,828	2,738	3,213	2,980	5,294	5,450	4,749
Electricity purchased	million kwh	1,291	1,527	1,518	1,586	1,659	1,818	1,980	2,171
	$000	8,660	9,751	9,820	10,177	10,699	11,467	13,059	14,430
Cost of fuel and electricity for small establishments[2]	$000	–	–	18	9	15	7	13	–
Total cost of fuel and electricity	$000	11,337	12,579	12,576	13,399	13,694	16,768	18,522	19,179
Total mineral manufacturing industries									
Fuel	$000	88,208	99,291	112,784	119,821	118,168	124,469	121,945	137,234
Electricity purchased	million kwh	12,295	15,261	15,729	17,832	17,764	19,299	20,532	19,980
	$000	65,875	74,011	80,605	87,742	91,285	101,867	109,470	126,593
Cost of fuel and electricity for small establishments[2]	$000	1,289	1,266	1,506	1,457	1,066	1,343	1,446	–
Total cost of fuel and electricity	$000	155,372	174,568	194,895	209,020	210,519	227,679	232,861	263,827

[1] Industry coverage is the same as in Tables 28, 30 and 33.
[2] Total cost of fuel and electricity purchased by small establishments; No detail reported.
– Nil.

Table 35. Canada, employment, salaries and wages in the mining industry*, 1963-1970

		1963	1964	1965	1966r	1967r	1968	1969	1970
Metals									
Production and related workers	Number	46,250	46,727	49,050	48,276	48,262	49,238	46,023	51,102
Salaries and wages	$000	235,839	244,549	269,457	284,477	317,978	350,321	341,495	421,893
Annual average salary and wage	$	5,099	5,234	5,494	5,893	6,589	7,115	7,420	8,256
Administrative and office workers	Number	10,869	10,921	11,892	13,394	13,466	14,131	14,527	15,488
Salaries and wages	$000	74,269	77,056	87,398	100,666	111,405	124,451	137,756	158,653
Annual average salary and wage	$	6,833	7,056	7,349	7,516	8,273	8,807	9,482	10,244
Total, Metals									
Employees	Number	57,119	57,648	60,942	61,670	61,728	63,369	60,550	66,590
Salaries and wages	$000	310,108	321,605	356,855	385,143	429,383	474,772	479,251	580,546
Annual average salary and wage	$	5,429	5,579	5,856	6,245	6,956	7,492	7,915	8,718
Nonmetals									
Production and related workers	Number	14,158	14,211	14,688	14,916	15,049	15,458	15,933	16,245
Salaries and wages	$000	62,370	67,134	72,352	77,984	84,755	94,850	107,622	114,345
Annual average salary and wage	$	4,405	4,724	4,926	5,228	5,632	6,135	6,754	7,039
Administrative and office workers	Number	3,189	3,560	3,676	3,818	3,807	4,051	4,081	4,250
Salaries and wages	$000	19,301	21,914	24,239	26,049	28,397	32,836	34,980	37,576
Annual average salary and wage	$	6,052	6,156	6,594	6,823	7,459	8,106	8,573	8,841
Total, Nonmetals									
Employees	Number	17,347	17,771	18,364	18,734	18,856	19,509	20,014	20,495
Salaries and wages	$000	81,671	89,048	96,591	104,033	113,152	127,686	142,602	151,921
Annual average salary and wage	$	4,708	5,011	5,260	5,553	6,000	6,545	7,125	7,413
Fuels									
Production and related workers	Number	11,454	11,399	11,308	11,003	10,919	10,370	9,412	9,861
Salaries and wages	$000	51,752	53,083	54,922	57,035	62,756	64,832	64,591	77,846
Annual average salary and wage	$	4,518	4,657	4,857	5,184	5,747	6,252	6,862	7,894
Administrative and office workers	Number	9,611	9,639	10,206	10,656	11,175	11,668	12,112	12,983
Salaries and wages	$000	65,285	66,991	73,733	83,021	95,387	105,163	118,395	131,744
Annual average salary and wage	$	6,793	6,950	7,224	7,791	8,536	9,013	9,775	10,147
Total Fuels									
Employees	Number	21,065	21,038	21,514	21,659	22,094	22,038	21,524	22,844
Salaries and wages	$000	117,037	120,074	128,655	140,056	158,143	169,995	182,986	209,590
Annual average salary and wage	$	5,556	5,707	5,980	6,466	7,158	7,714	8,501	9,175

(continued on page 556)

Table 35. (concl'd)

		1963	1964	1965	1966[r]	1967[r]	1968	1969	1970
Total Mining									
Production and related workers	Number	71,862	72,337	75,046	74,195	74,230	75,066	71,368	77,208
Salaries and wages	$000	349,961	364,766	396,731	419,496	465,489	510,003	513,708	614,084
Annual average salary and wage	$	4,870	5,043	5,286	5,654	6,271	6,794	7,198[r]	7,953
Administrative and office workers	Number	23,669	24,120	25,774	27,868	28,448	29,850	30,720	32,721
Salaries and wages	$000	158,855	165,961	185,370	209,736	235,189	262,450	291,131	327,973
Annual average salary and wage	$	6,712	6,881	7,192	7,526	8,267	8,792	9,477	10,023
Total Mining									
Employees	Number	95,531	96,457	100,820	102,063	102,678	104,916	102,088	109,929
Salaries and wages	$000	508,816	530,727	582,101	629,232	700,678	722,453	804,839	942,057
Annual average salary and wage	$	5,326	5,502	5,774	6,165	6,824	7,363	7,883	8,570

*According to the revised Standard Industrial Classification. Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing. These industries are included in Table 36 under Nonmetallic Mineral Products Industries.
See Table 27 for detail of industries covered.
[r]Revised.

Table 36. Canada, employment, salaries and wages in the mineral manufacturing industries, 1963-1970

		1963	1964	1965	1966	1976	1968	1969	1970
Primary Metal Industries									
Production and related workers	Number	72,352	77,770	83,443	87,748	86,784	86,237	83,564	88,839
Salaries and wages	$000	383,356	427,710	478,482	518,347	541,970	570,183	583,498	680,779
Annual average salary and wage	$	5,298	5,550	5,734	5,907	6,245	6,612	6,982	7,663
Administrative and office workers	Number	19,269	20,010	21,189	22,555	23,294	23,702	24,300	27,706
Salaries and wages	$000	126,067	133,866	148,752	169,686	185,800	202,683	219,807	277,728
Annual average salary and wage	$	6,542	6,690	7,020	7,523	7,976	8,551	9,045	10,024
Total Primary Metal Industries									
Employees	Number	91,621	97,780	104,632	110,303	110,078	109,939	107,864	116,545
Salaries and wages	$000	509,423	561,576	627,234	688,033	727,770	772,866	803,305	958,507
Annual average salary and wage	$	5,560	5,743	5,995	6,238	6,611	7,030	7,447	8,224
Nonmetallic Mineral Products Industries									
Production and related workers	Number	33,740	35,598	38,246	39,561	37,467	37,796	38,107[r]	36,045
Salaries and wages	$000	148,305	164,302	188,351	206,120	207,204	223,173	246,196	244,201
Annual average salary and wage	$	4,396	4,615	4,925	5,210	5,569	5,919	6,461[r]	6,775
Administrative and office workers	Number	10,747	11,273	11,044	11,583	11,793	16,191	11,781	13,383
Salaries and wages	$000	59,552	64,890	66,970	73,851	79,464	106,557	94,243	117,163
Annual average salary and wage	$	5,541	5,756	6,064	6,376	6,738	6,581	7,999	8,754

Table 36. (concl'd)

		1963	1964	1965	1966	1976	1968	1969	1970
Total Nonmetallic Mineral Products									
Employees	Number	44,487	46,871	49,290	51,144	49,260	53,987	49,888	49,428
Salaries and wages	$000	207,857	229,192	255,321	279,971	286,668	329,730	340,439	361,364
Annual average salary and wage	$	4,672	4,890	5,180	5,474	5,819	6,108	6,824	7,311
Petroleum and Coal Products Industries									
Production and related workers	Number	7,281	7,168	6,825	6,832	6,839	6,876	6,590	6,686
Salaries and wages	$000	43,369	44,784	43,387	48,780	52,462	56,703	61,217	64,745
Annual average salary and wage	$	5,956	6,248	6,357	7,140	7,671	8,247	9,289	9,684
Administrative and office workers	Number	3,441	3,478	3,090	3,173	3,264	3,130	3,145	8,961
Salaries and wages	$000	23,607	24,884	25,472	26,540	28,287	29,422	32,134	95,908
Annual average salary and wage	$	6,961	7,155	8,243	8,364	8,666	9,400	10,217	10,703
Total Petroleum and Coal Products									
Employees	Number	10,722	10,646	9,915	10,005	10,103	10,006	9,735	15,647
Salaries and wages	$000	66,976	69,668	68,859	75,320	80,749	86,125	93,351	160,653
Annual average salary and wage	$	6,247	6,546	6,945	7,528	7,993	8,607	9,589	10,267
Total Mineral Manufacturing Industries									
Production and related workers	Number	113,373	120,536	128,514	134,141	131,090	130,909	128,261	131,570
Salaries and wages	$000	575,030	636,796	710,220	773,247	801,636	850,059	890,911	989,725
Annual average salary and wage	$	5,072	5,283	5,526	5,764	6,115	6,494	6,945	7,522
Administrative and office workers	Number	33,457	34,761	35,323	37,311	38,351	43,023	39,226	50,050
Salaries and wages	$000	209,226	223,640	241,194	270,077	293,551	338,662	346,184	490,799
Annual average salary and wage	$	6,254	6,434	6,828	7,239	7,654	7,872	8,825	9,806
Total Mineral Manufacturing Industries									
Employees	Number	146,830	155,297	163,837	171,452	169,441	173,932	167,487[r]	181,620
Salaries and wages	$000	784,256	860,436	951,414	1,043,324	1,095,187	1,188,721	1,237,095	1,480,524
Annual average salary and wage	$	5,341	5,541	5,807	6,085	6,464	6,834	7,386	8,151

Note: See footnote Table 35.
See Table 28 for detail of industries covered.
[r]Revised.

Table 37. Canada, number of wage earners, surface, underground and mill, mining industry*, 1967-1970

	1967	1968	1969	1970
Metals				
Surface	13,864	14,061	13,269	14,724
Underground	25,482	25,146	22,996	25,317
Mill	8,916	10,031	9,758	11,061
Total	48,262	49,238	46,023	51,102
Nonmetals				
Surface	8,310	7,575	7,381	7,515
Underground	1,382	1,483	1,817	1,954
Mill	5,357	6,400	6,735	6,776
Total	15,049	15,458	15,933	16,245
Fuels				
Surface	5,380	5,222	4,292	5,091
Underground	5,539	5,148	5,120	4,770
Total	10,919	10,370	9,412	9,861
Total mining industry				
Surface	27,554	26,858	24,942	27,330
Underground	32,403	31,777	29,933	32,041
Mill	14,273	16,431	16,493	17,837
Total	74,230	75,066	71,368	77,208

*See Table 27 for coverage.

Table 38. Canada, labour costs in relation to tons mined, metal mines, 1968-1970

Type of Metal Mine	Number of Wage Earners	Total Wages $000	Average Annual Wage $	Tons of Ore Mined 000st	Average Annual Tons Mined Per Wage Earner	Wage Cost Per Ton Mined $
1970						
Auriferous quartz	5,982	36,203	6,052	7,782	1,301	4.65
Copper-gold-silver	11,826	90,980	7,693	43,067	3,642	2.11
Nickel-copper	16,691	149,303	8,945	34,492	2,067	4.33
Silver-cobalt	339	2,203	6,499	230	679	9.58
Silver-lead-zinc	4,987	39,235	7,868	15,839	3,176	2.48
Iron ore	7,609	74,031	9,729	108,260	14,228	0.68
Miscellaneous metals	3,660	29,906	8,171	25,200	6,885	1.19
Total	51,094	421,861	8,257	234,870	4,597	1.80
1969						
Auriferous quartz	6,947	39,112	5,630	9,048	1,302	4.32
Copper-gold-silver	10,627	73,721	6,937	33,847	3,185	2.18
Nickel-copper	12,425	94,999	7,646	22,244	1,790	4.27
Silver-cobalt	430	2,599	6,044	286	665	9.09
Silver-lead-zinc	4,772	34,191	7,164	14,192	2,974	2.41
Iron ore	7,058	66,960	9,487	88,142	12,488	0.76
Miscellaneous metals	3,752	29,876	7,962	21,819	5,815	1.37
Total	46,011	341,458	7,421	189,578	4,120	1.80
1968						
Auriferous quartz	7,616	40,493	5,316	9,269	1,217	4.37
Copper-gold-silver	10,423	69,420	6,660	34,909	3,349	1.99
Nickel-copper	14,980	115,264	7,695	29,651	1,979	3.88
Silver-cobalt	470	2,675	5,691	269	572	9.94
Silver-lead-zinc	4,645	30,994	6,673	12,503	2,691	2.47
Iron ore	7,830	68,179	8,707	101,753	12,995	0.67
Miscellaneous metals	3,256	23,197	7,124	17,702	5,436	1.31
Total	49,220	350,222	7,115	206,056	4,186	1.70

Table 39. Canada, man-hours paid, production and related workers, tons of ore mined and rock quarried, metal mines and nonmetallic mineral operations, 1964-1970

	Unit	1964	1965	1966	1967	1968	1969	1970
Metal mines[1]								
Ore mined	million st	141.1	166.5	162.8	186.5	206.1	189.6	234.9
Man-hours paid[2]	million	100.7	106.4	101.4	103.8	105.2	95.8	108.2
Man-hours paid per ton mined	number	0.71	0.64	0.62	0.56	0.51	0.51	0.46
Tons mined per man-hour paid	st	1.40	1.56	1.61	1.80	1.96	1.98	2.17
Nonmetallic mineral operations[3]								
Ore mined and rock quarried	million st	132.9	144.0	171.3	177.9	173.4	179.9	178.0
Man-hours paid[2]	million	24.0	23.2	24.7	25.3	25.9	28.4 [r]	28.6
Man-hours paid per ton mined	number	0.18	0.16	0.14	0.14	0.15	0.16[r]	0.16
Tons mined per man-hour paid	st	5.54	6.19	6.93	7.04	6.69	6.33[r]	6.22

[1] Excludes placer mining. [2] Man-hours paid for production and related workers only. [3] Excludes salt, cement, clay products, stone for cement and lime manufacture, and peat.
[r] Revised.

Table 40. Canada, basic wage rates per hour in metal mining industry on October 1, 1971 and 1972

	Gold mines		Iron Mines		Other Metal Mines	
	1971	1972p	1971	1972p	1971	1972p
	$	$	$	$	$	$
Underground workers						
Cage and skiptender	2.54	2.88	..	..	3.64	4.07
Chute blaster	2.52	2.80	..	..	3.78	4.26
Deckman	2.42	2.75	..	..	3.41	3.84
Hoistman	2.74	3.06	..	..	3.92	4.34
Labourer	2.51	2.69	..	..	3.48	3.85
Miner	2.56	2.91	..	..	3.59	4.08
Miner's helper	2.33	2.53	..	..	2.92	3.24
Motorman	2.39	2.68	..	..	3.57	3.77
Mucking machine operator	2.45	2.79	..	..	3.53	3.88
Mucker and trammer	2.38	2.78	..	..	3.44	3.97
Timberman	2.51	2.93	..	..	3.47	3.97
Trackman	2.41	2.78	..	..	3.46	3.96
Open-pit workers						
Blaster	..	..	3.76	4.21	..	..
Bulldozer operator	..	..	3.77	4.30	..	..
Driller machine	..	..	3.90	4.36	..	..
Dumptruck driver	..	..	3.89	4.38	..	..
Oiler	..	..	3.52	4.00	..	..
Shovel operator (power)	..	..	4.36	4.85	..	..
Surface and mill workers						
Blacksmith	..	..	..	..	3.87	4.30
Carpenter, maintenance	2.80	3.04	4.21	4.71	3.85	4.25
Crusher operator	2.51	2.76	3.68	4.18	3.55	3.91
Electrician	2.81	3.12	4.35	4.85	4.18	4.65
Filter operator	..	..	..	..	3.42	3.88
Flotation operator	..	..	..	..	3.65	4.00
Grinding-mill operator	..	..	3.80	4.19	3.58	3.96
Hoistman	..	..	..	..	..	..
Labourer	2.37	2.59	3.23	3.70	3.10	3.52
Machinist maintenance	2.92	3.48	4.41	4.94	4.17	4.62
Mechanic, diesel	..	..	4.30	4.84	4.34	4.76
Mechanic maintenance	2.66	2.95	4.20	4.73	4.01	4.50
Millman*	2.56	2.91	..	..	..	..
Pipefitter, maintenance	2.62	3.02	4.18	4.72	3.89	4.19
Solution man	..	..	..	..	3.55	3.96
Steel sharpener	2.56	2.98	..	..	3.86	3.88
Trademan's helper	2.65	2.74	3.53	3.99	3.41	3.79
Truck driver, light and heavy	2.41	2.74	3.70	4.17	3.67	4.00
Welder, maintenance	2.71	3.05	4.23	4.73	4.08	4.55
Millwright	..	..	4.30	4.76	4.19	4.62

*Includes filter operator, grinding-mill operator (ball-mill operator, rod-mill operator, tubeman) and solution man.
pPreliminary; .. Not available or not applicable.

Table 41. Canada, index numbers of average wage rates*, by industries 1967-1972. Base year 1961 = 100

	1967	1968	1969	1970	1971	1972
Logging	156.0	162.5	179.8	192.8	212.3	226.1
Metal mining	130.2	138.9	146.2	159.4	169.9	190.1
Gold-quartz	142.7	154.5	161.6	171.3	179.5	203.9
Iron	129.0	133.2	147.1	158.1	166.0	187.0
Other metal	125.6	134.1	140.0	155.1	167.1	185.4
Manufacturing	130.5	140.6	151.2	162.9	176.3	190.8
Non-durable	131.0	141.4	152.5	163.2	176.9	191.5
Petroleum refineries	131.4	139.3	146.2	162.0	175.4	188.8
Durable	130.0	139.7	149.7	162.3	175.7	190.1
Primary metal industries	123.1	128.5	135.1	154.5	165.8	182.8
Metal fabricating industries	131.2	140.4	151.9	162.7	176.8	190.9
Machinery industries	131.0	140.5	151.8	163.3	173.0	187.2
Transportation equipment industries	131.7	142.1	152.8	164.2	179.5	193.5
Electrical products industries	123.4	133.8	141.7	151.0	163.4	170.4
Construction	142.0	154.9	167.0	195.5	223.7	239.9
Transportation, communication and other utilities	132.8	143.4	154.9	166.2	183.8	196.6
Trade	132.5	144.5	155.2	166.1	178.9	195.7
Service	133.9	141.8	154.0	166.4	178.0	191.7
Local government (municipal government only)	136.9	146.7	163.4	183.3	200.2	217.2
General Index, all industries	133.4	143.8	155.1	167.8	182.3	197.4

*The weighted average of straight-time rates paid on a time basis in an occupation.

Table 42. Canada, average weekly wages and hours of hourly-rated employees in mining, manufacturing and construction industries, 1965-1972

	1965	1966	1967	1968	1969	1970	1971	1972p
Mining								
Average hours per week	42.5	42.3	41.9	41.8	41.4	41.0	40.4	40.2
Average weekly wage	103.30	110.29	119.09	128.28	135.94	152.10	163.22	174.47
Metals								
Average hours per week	41.9	41.6	41.3	41.2	40.7	40.3	39.3	38.9
Average weekly wage	105.76	112.99	112.79	131.55	137.68	154.68	164.27	174.27
Mineral fuels								
Average hoùrs per week	41.3	42.3	42.5	41.9	41.9	42.0	41.4	40.9
Average weekly wage	89.07	95.68	101.24	109.96	122.88	146.68	161.46	176.28
Nonmetals								
Average hours per week	42.7	42.1	42.3	42.4	41.9	41.3	41.4	41.2
Average weekly wage	99.49	104.00	112.35	121.24	129.05	139.21	151.52	158.21
Manufacturing								
Average hours per week	41.0	40.8	40.3	40.3	40.0	39.7	39.7	40.0
Average weekly wage	86.89	91.65	96.84	104.00	111.69	119.69	130.22	141.60
Construction								
Average hours per week	41.3	42.2	41.3	40.5	39.6	39.2	39.2	40.2
Average weekly wage	104.45	118.23	128.76	134.84	146.90	165.04	186.20	207.43

pPreliminary.

Table 43. Canada, average weekly wages of hourly-rated employees in mining industry in current and 1949 dollars, 1965-1972

	1965	1966	1967	1968	1969	1970	1971	1972p
Current Dollars								
All mining	103.30	110.29	119.09	128.28	135.94	152.10	163.22	174.47
Metals	105.76	112.99	122.79	131.55	137.68	154.68	164.27	174.27
Gold	84.71	91.12	95.72	101.26	107.69	113.72	124.61	132.44
Mineral fuels	89.07	95.68	101.24	109.96	122.88	146.68	161.46	176.28
Coal	80.68	85.53	90.63	97.41	108.58	130.37	144.26	157.99
Industrial minerals	99.49	104.00	112.35	121.24	129.05	139.21	151.52	158.21
1949 Dollars								
All mining	74.48	76.64	79.92	82.65	83.86	90.81	94.73	96.61
Metals	76.25	78.52	82.40	84.76	84.94	92.35	95.34	96.50
Gold	61.07	63.32	64.24	65.24	66.43	67.89	72.32	73.33
Mineral fuels	64.22	66.49	67.94	70.85	75.81	87.57	93.71	97.61
Coal	58.17	59.44	60.83	62.76	66.98	77.83	83.73	87.48
Industrial minerals	71.73	72.27	75.40	78.12	79.61	83.11	87.94	87.60

pPreliminary.

Table 44. Canada, industrial fatalities per thousand workers, by industry groups, 1970-1972

	Fatalities number			Number of Workers 000's			Rate per 1,000 Workers		
	1970	1971	1972	1970	1971	1972	1970	1971	1972p
Agriculture	16	21	30	511	510	481	0.03	0.04	0.06
Forestry	94	93	76	72	72	71	1.31	1.29	1.07
Fishing	25	11	10	20	22	22	1.25	0.50	0.45
Mining	150	162	171	125	129	124	1.20	1.26	1.38
Manufacturing	182	181	247	1,790	1,795	1,857	0.10	0.10	0.13
Construction	194	225	208	471	495	501	0.41	0.45	0.42
Transportation	187	203	225	692	702	730	0.27	0.29	0.31
Trade	62	79	70	1,320	1,330	1,410	0.05	0.06	0.05
Finance	3	4	6	365	385	385	0.008	0.01	0.02
Service	55	70	109	2,025	2,118	2,194	0.03	0.03	0.05
Public Administration	80	67	63	486	520	553	0.16	0.13	0.11
Total	1,048	1,116	1,215	7,877	8,078	8,328	0.13	0.14	0.15

See footnotes Table 45.
pPreliminary.

Table 45. Canada, industrial fatalities per thousand workers, by industry groups, 1962-1972

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972[p]
Agriculture	0.09	0.08	0.11	0.08	0.10	0.05	0.05	0.06	0.03	0.04	0.06
Forestry	1.72	1.53	1.89	1.40	1.45	1.25	1.28	1.10	1.31	1.29	1.07
Fishing[1]	0.52	1.36	1.42	1.74	1.42	1.32	0.79	0.86	1.25	0.50	0.45
Mining[2]	1.86	2.26	1.85	1.31	1.21	1.61	1.15	1.40	1.20	1.26	1.38
Manufacturing	0.14	0.14	0.14	0.14	0.13	0.11	0.10	0.11	0.10	0.10	0.13
Construction	0.52	0.58	0.61	0.60	0.59	0.43	0.46	0.49	0.41	0.45	0.42
Transportation[3]	0.36	0.35	0.40	0.47	0.40	0.34	0.26	0.30	0.27	0.29	0.31
Trade	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.05
Finance[4]	0.01	0.01	0.01	0.01	0.00	0.02	–	0.01	0.01	0.01	0.02
Service[5]	0.01	0.02	0.04	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.05
Public Administration	0.22	0.29	0.14	0.13	0.07	0.08	0.14	0.14	0.16	0.13	0.11
Composite	0.18	0.19	0.20	0.19	0.17	0.15	0.13	0.14	0.13	0.14	0.15

[1]Includes trapping and hunting; [2]Includes quarrying and oil wells; [3]Includes storage, communication, electric power and water utilities; [4]Includes insurance and real estate; [5]Includes community, business and personal service.
[p]Preliminary.

Table 46. Canada, number of strikes and lockouts, by industries, 1971-1972

	1971			1972P		
	Strikes and Lockouts	Workers Involved	Duration in Man-Days	Strikes and Lockouts	Workers Involved	Duration in Man-Days
Forestry	27	4,203	49,480	12	6,004	120,330
Fishing and trapping	1	4,500	40,500	–	–	–
Mines	19	7,680	193,490	32	13,410	334,680
Manufacturing	278	94,331	1,541,520	290	117,699	2,042,500
Construction	73	23,868	400,990	82	50,649	1,420,460
Transportation and utilities	54	45,764	254,270	59	54,151	1,351,130
Trade	46	4,857	81,040	47	4,104	55,060
Finance, insurance and real estate	1	227	1,140	2	231	1,770
Service	43	43,109	220,440	35	7,659	83,420
Public administration	27	11,092	83,720	39	452,567	2,344,180
All industries	569	239,631	2,866,590	598	706,474	7,753,530

– Nil; PPreliminary.

Table 47. Canada, ore mined and rock quarried, mining industry, 1968-70

	1968	1969	1970
		(short tons)	
Metals			
Gold quartz	9,268,857	9,048,327	7,781,571
Copper-gold-silver	34,909,280	33,847,436	43,067,354
Silver-cobalt	269,036	286,097	229,704
Silver-lead-zinc	12,503,061	14,191,584	15,838,543
Nickel-copper	29,650,613	22,243,976	34,492,189
Iron	101,753,446	88,142,291	108,259,551
Miscellaneous metals	17,702,304	21,818,907	25,199,823
Total	206,056,597	189,578,618	234,868,735
Nonmetals			
Asbestos	78,115,612	88,438,106	90,531,936
Feldspar, nepheline syenite	662,046	791,053	626,833
Quartz (exclusive of sand)	1,101,805	1,268,446	1,368,952
Gypsum	5,914,312	6,625,859	5,892,699
Talc soapstone	87,588	74,178	67,021
Rock salt	3,865,097	3,406,901	4,368,015
Other nonmetallics	11,598,754	15,257,175	14,304,219
Total	101,345,214	115,861,718	117,159,675
Structural materials			
Stone, all kinds quarried	75,939,767	67,477,012	65,322,840
Stone used to make cement	10,501,240	10,774,284	11,774,537
Stone used to make lime	2,531,850	2,981,494	3,118,403
Total	88,972,857	81,232,790	80,215,780
Total ore mined and rock quarried	396,374,668	386,673,126	432,244,190

Table 48. Canada, ore mined and rock quarried, mining industry, 1936-1970

	Metals	Nonmetals*	Total
		(million short tons)	
1936	22.7	13.0	35.7
1937	28.1	17.7	45.8
1938	31.4	14.9	46.3
1939	35.9	16.5	52.4
1940	39.6	20.3	59.9
1941	43.0	21.6	64.6
1942	42.5	21.7	64.2
1943	38.7	20.7	59.4
1944	35.3	19.3	54.6
1945	31.3	20.6	51.9
1946	28.9	24.8	53.7
1947	33.3	30.4	63.7
1948	36.9	33.5	70.4
1949	43.3	32.9	76.2
1950	45.9	41.8	87.7
1951	48.8	43.8	92.6
1952	52.3	44.2	96.5
1953	54.4	47.2	101.6
1954	59.0	61.5	120.5
1955	69.2	63.5	132.7
1956	77.4	73.0	150.4
1957	84.3	82.2	166.5
1958	78.8	78.5	157.3
1959	99.1	90.7	189.8
1960	101.6	97.8	199.4
1961	99.4	106.7	206.1
1962	114.3	114.5	228.8
1963	124.3	132.8	257.1
1964	141.1	147.8	288.9
1965	166.5	161.5	328.0
1966	162.8	189.4	352.2
1967	186.5	195.7	382.2
1968	206.1	190.3	396.4
1969	189.6	197.1	386.7
1970	234.9	197.3	432.2

*Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. Excludes coal.

Coverage is the same as in Table 47.

Table 49. Canada, exploration and capital expenditures in the mining industry[1], by provinces, 1970-1972

		Capital						Repair						
		Construction												
		On Property Exploration	On Property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
Atlantic Provinces	1970	2.0	10.1	8.0	20.1	16.2	36.3	5.0	49.2	54.2	90.5	6.4	0.7	97.6
	1971	. .	. .	. .	80.7	29.0	109.7	5.3	49.6	54.9	164.6	2.9	–	167.5
	1972P	1.7	10.2	11.2	23.1	71.6	94.7	6.3	48.1	54.4	149.1	2.7	–	151.8
Quebec	1970	3.2	33.4	24.7	61.3	40.8	102.1	9.2	64.1	73.3	175.4	8.8	2.1	186.3
	1971	6.4	25.5	112.7	144.6	106.0	250.6	7.3	71.8	79.1	329.7	11.0	2.7	343.4
	1972P	2.5	30.5	121.8	154.8	159.7	314.5	5.9	75.4	81.3	395.8	8.5	1.8	406.1
Ontario	1970	10.7	70.8	42.6	124.1	79.6	203.7	17.5	118.4	135.9	339.6	32.2	0.5	372.3
	1971	8.7	72.5	43.5	124.7	92.6	217.3	19.0	121.1	140.1	357.4	21.3	2.4	381.1
	1972P	5.7	56.1	23.9	85.7	79.6	165.3	8.1	123.1	131.2	296.5	15.3	1.7	313.5
Manitoba	1970	4.6	33.4	11.0	49.0	16.6	65.6	4.0	12.0	16.0	81.6	9.3	–	91.4
	1971	4.1	17.8	8.3	30.2	9.5	39.7	4.6	14.8	19.4	59.1	9.4	–	68.5
	1972P	. .	. .	. .	31.1	15.6	46.7	2.4	13.2	15.6	62.3	5.4	–	67.7
Saskatchewan	1970	0.1	6.7	9.0	15.8	25.0	40.8	2.6	17.8	20.4	61.2	6.6	0.3	68.1
	1971	–	4.8	1.8	6.6	6.0	12.6	3.6	19.0	22.6	35.2	5.6	0.1	40.9
	1972P	. .	. .	. .	9.1	11.8	20.9	2.1	21.6	23.7	44.6	3.7	. .	. .
Alberta	1970	. .	. .	. .	18.5	17.8	36.3	0.5	7.7	8.2	44.5	2.5	0.1	47.1
	1971	. .	. .	. .	8.5	8.1	16.6	0.5	5.9	6.4	23.0	5.1	0.5	28.6
	1972P	. .	. .	. .	7.2	5.2	12.4	0.3	5.5	5.8	18.2	1.8	. .	. .
British Columbia	1970	3.1	60.8	69.6	133.5	63.2	196.7	3.7	42.0	45.7	242.4	37.4	0.9	280.7
	1971	3.8	32.7	173.0	209.5	138.9	348.4	3.7	53.4	57.1	405.5	27.7	1.2	434.4
	1972P	2.1	25.5	44.3	71.9	48.0	119.9	6.4	60.0	66.4	186.3	27.0	. .	. .
Yukon and Northwest Territories	1970	2.0	11.9	7.3	21.2	7.0	28.2	1.2	8.9	10.1	38.3	15.1	0.4	53.8
	1971	1.7	14.3	4.5	20.5	5.4	25.9	1.2	14.0	15.2	41.1	8.3	0.4	49.8
	1972P	2.2	15.0	2.9	20.1	2.9	23.0	0.9	13.9	14.8	37.8	6.7	. .	. .
Canada	1970	. .	. .	. .	443.5	266.2	709.7	43.7	320.1	363.8	1,073.5	118.8	5.0	1,197.3
	1971	27.2	188.3	409.8	625.3	395.5	1,020.8	45.2	349.6	394.8	1,415.6	91.3	7.3	1,514.2
	1972P	16.6	159.4	227.0	403.0	394.4	797.4	32.4	360.8	393.2	1,190.6	71.1	12.6	1,274.3

[1] Excludes the petroleum and natural gas industries and the smelting and refining industries.
Industry coverage is the same as in Table 50.
. . Not available for publication because of confidentiality.
PPreliminary.
– Nil.

Table 50. Exploration and capital expenditures[1] in the mining industry, by type of mining, 1970-1972

		Capital						Repair						
		On Property Exploration	On Property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
Metal Mining														
Gold	1970	0.5	9.3	1.5	11.3	2.2	13.5	0.5	3.5	4.0	17.5	3.7	–	21.2
	1971	0.4	6.8	2.2	9.4	2.4	11.8	0.6	3.8	4.4	16.2	1.2	–	17.4
	1972P	0.6	8.4	0.3	9.3	1.6	10.9	0.4	4.8	5.2	16.1	1.0	–	17.1
Copper-gold-silver	1970	4.7	66.8	65.1	136.6	47.3	183.9	4.9	34.6	39.5	223.4	7.5	0.3	231.2
	1971	4.9	48.9	159.5	213.3	127.4	340.7	5.1	43.4	48.5	389.2	3.2	0.5	392.9
	1972P	4.0	45.9	71.4	121.3	105.5	226.8	7.6	51.6	59.2	286.0	7.2	0.5	293.7
Silver-lead-zinc	1970	2.9	10.0	3.2	16.1	6.5	22.6	1.6	12.5	14.1	36.7	3.5	0.2	40.4
	1971	2.8	12.6	3.2	18.6	7.3	25.9	1.6	15.4	17.0	42.9	2.2	0.1	45.2
	1972P	3.3	12.7	2.9	18.9	7.0	25.9	1.7	16.3	18.0	43.9	1.3	0.4	45.6
Uranium[2]	1970	–	4.6	1.0	5.6	0.8	6.4	0.6	5.0	5.6	12.0	1.5	–	13.5
	1971	–	3.7	0.3	4.0	1.9	5.9	1.3	4.2	5.5	11.4	1.8	–	13.2
	1972P	..	..	..	..	..	..	..	..	..	..	..	..	..
Iron[3]	1970	0.4	20.4	9.1	29.9	20.7	50.6	11.2	81.6	92.8	143.4	0.5	0.2	144.1
	1971	..	..	..	..	..	..	9.6	86.9	..	..	0.6	–	..
	1972P	..	..	..	..	127.5	..	9.0	82.8	..	..	0.7	–	..
Other metal mining	1970	14.0	74.0	44.6	132.6	71.4	204.0	17.8	82.8	100.6	304.6	8.4	–	313.0
	1971	13.6	91.6	187.1	292.3	150.3	442.6	19.1	88.7	107.8	646.9	6.7	0.2	653.8
	1972P	..	..	..	64.4	..	..	7.6	86.9	94.5	..	7.3	0.3	..
Total metal mining	1970	22.5	185.1	124.5	332.1	148.9	481.0	36.6	220.0	256.6	737.6	25.1	0.7	763.4
	1971	21.7	163.6	352.3	537.6	289.3	826.9	37.3	242.4	279.7	1,106.6	15.7	0.8	1,123.1
	1972P	13.7	125.2	202.5	341.4	312.7	654.1	26.3	242.4	268.7	922.8	17.5	1.2	941.5
Nonmetal mining														
Asbestos	1970	1.1	10.6	18.2	29.9	29.7	59.6	1.7	31.3	33.0	92.6	0.3	1.8	94.7
	1971	2.7	14.2	19.4	36.3	29.3	65.6	1.9	35.2	37.1	102.7	0.3	..	..
	1972P	0.3	19.4	9.7	29.4	27.9	57.3	2.6	32.8	35.4	92.7	0.2	..	..
Miscellaneous nonmetal mining[4]	1970	..	..	..	15.0	29.5	44.3	2.4	19.2	21.6	66.1	0.5	0.6	75.3
	1971	0.2	3.6	2.6	6.4	11.8	18.2	3.3	20.2	23.5	41.7	0.2	..	..
	1972P	1.9	13.7	14.6	30.2	53.2	83.5	3.4	85.5	88.9	172.4	0.8	..	..

Table 50. Exploration and capital expenditures[1] in the mining industry, by type of mining, 1970-1972 (Cont'd)

		Capital						Repair						
		On Property Exploration	On Property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
Other nonmetal mining[5]	1970	..	..	..	63.0	56.7	101.4	3.0	49.4	52.4	172.1	2.3	–	174.4
	1971	1.5	5.1	35.3	41.9	64.5	106.4	2.7	51.7	54.4	160.8	3.8	..	..
	1972P	..	..	..	..	..	..	..	..	..	..	..	..	..
Total nonmetal	1970	..	..	..	107.9	115.9	205.3	7.1	99.9	107.0	330.8	3.1	2.4	336.3
	1971	4.4	22.9	57.3	84.6	105.6	190.2	7.9	107.1	115.0	305.2	4.3	4.8	314.3
	1972P	2.2	33.1	24.3	59.6	81.2	140.8	6.0	118.3	124.3	265.1	1.0	8.9	275.0
Metal and nonmetal mining exploration	1970	1.1	1.7	0.7	3.5	1.4	4.9	–	0.2	0.2	5.1	90.6	1.9	97.6
	1971	1.1	1.8	0.2	3.1	0.6	3.7	–	0.1	0.1	3.8	71.3	1.7	76.8
	1972P	0.7	1.1	0.2	2.0	0.5	2.5	0.1	0.1	0.2	2.7	52.6	2.5	57.8
Total Mining	1970	..	..	..	443.5	266.2	709.7	43.7	320.1	363.8	1,073.5	118.8	5.0	1,197.3
	1971	27.2	188.3	409.8	625.3	395.5	1,020.8	45.2	349.6	394.8	1,415.6	91.3	7.3	1,514.2
	1972P	16.6	159.4	227.0	403.0	394.4	797.4	32.4	360.8	393.2	1,190.6	71.1	12.6	1,274.3

[1] Excludes expenditures in the petroleum and natural gas industries.
[2] Not available separately for uranium mines in 1972, included under "other metal mining".
[3] Not completely available for iron mining in 1971 and 1972. Confidential figures are included and under "total metal mining".
[4] Includes SIC 079 "miscellaneous nonmetal mining".
[5] Includes coal, gypsum and salt mines, stone quarries and sand pits.
[6] Included under "miscellaneous nonmetal mines in 1972".
–Nil.
.. Not available.
P Preliminary.

Table 51. Canada, diamond drilling in the mining industry by mining companies with own equipment and by drilling contractors, 1969-1970

		1969			1970		
		Exploration	Other	Total	Exploration	Other	Total
		(footage)					
Metal mining							
Gold quartz	own equipment	54,435	484	54,919	72,373	–	72,373
	contractors	653,485	191,893	845,378	540,754	91,328	632,082
	Total	707,920	192,377	900,297	613,127	91,328	704,455
Copper-gold-silver	own equipment	35,595	113,482	149,077	41,103	103,606	144,709
	contractors	1,592,597	101,859	1,694,456	1,563,346	128,386	1,691,732
	Total	1,628,192	215,341	1,843,533	1,604,449	231,992	1,836,441
Nickel-copper	own equipment	241,425	172,841	414,266	56,567	346,123	402,690
	contractors	476,569	295,332	771,901	939,468	538,316	1,477,784
	Total	717,994	468,173	1,186,167	996,035	884,439	1,880,474
Silver-lead-zinc and silver cobalt	own equipment	109,108	440	109,548	30,821	502,908	533,729
	contractors	534,672	4,305	538,977	670,289	26,362	696,651
	Total	643,780	4,745	648,525	701,110	529,270	1,230,380
Molybdenum	own equipment	–	–	–	–	–	–
	contractors	50,935	–	50,935	65,082	–	65,082
	Total	50,935	–	50,935	65,082	–	65,082
Iron mines	own equipment	–	–	–	–	–	–
	contractors	57,800	6,672	64,472	118,622	7,778	126,400
	Total	57,800	6,672	64,472	118,622	7,778	126,400
Miscellaneous metal mining	own equipment	3,373	–	3,373	3,032	–	3,032
	contractors	152,080	88,697	240,777	131,513	–	131,513
	Total	155,453	88,697	244,150	134,545	–	134,545
Total metal mining	own equipment	443,936	287,247	731,183	203,896	952,637	1,156,533
	contractors	3,518,138	688,758	4,206,896	4,029,074	792,170	4,821,244
	Total	3,962,074	976,005	4,938,079	4,232,970	1,744,807	5,977,777

Table 51. Canada, diamond drilling in the mining industry by mining companies with own equipment and by drilling contractors, 1969-1970 (Cont'd)

		1969			1970		
		Exploration	Other	Total	Exploration	Other	Total
				(footage)			
Nonmetal mining							
Asbestos	own equipment	–	–	–	–	11,388	11,388
	contractors	70,779	76,092	146,871	76,092	–	76,092
	Total	70,779	76,092	146,871	76,092	11,388	87,480
Feldspar and quartz	own equipment	–	–	–	–	–	–
	contractors	5,816	–	5,816	6,917	–	6,917
	Total	5,816	–	5,816	6,917	–	6,917
Gypsum	own equipment	–	–	–	–	–	–
	contractors	14,553	–	14,553	5,325	–	5,325
	Total	14,553	–	14,553	5,325	–	5,325
Salt	own equipment	–	–	–	6,578	–	6,578
	contractors	17,487	–	17,487	–	–	–
	Total	17,487	–	17,487	6,578	–	6,578
Miscellaneous non-metal mining	own equipment	3,478	–	3,478	6,702	–	6,702
	contractors	1,636	–	1,636	6,150	–	6,150
	Total	5,114	–	5,114	12,852	–	12,852
Total nonmetal mining	own equipment	3,478	–	3,478	13,280	11,388	24,668
	contractors	110,271	76,092	186,363	94,484	–	94,484
	Total	113,749	76,092	189,841	107,764	11,388	119,152
Total Mining Industry	own equipment	447,414	287,247	734,661	217,176	964,025	1,181,201
	contractors	3,628,409	764,850	4,393,259	4,123,558	792,170	4,915,728
	Total	4,075,823	1,052,097	5,127,920	4,340,734	1,756,195	6,096,929

– Nil.

Table 52. Canada, total diamond drilling on metal deposits by mining companies with own equipment and by drilling contractors, 1957-1970

	Gold-Quartz Deposits	Copper-Gold-Silver and Nickel-Copper Deposits	Silver-Lead Zinc and Silver-Cobalt Deposits	Other Metal-Bearing Deposits*	Total Metal Deposits
			(footage)		
1957	1,846,621	3,603,971	1,062,020	942,794	7,455,406
1958	1,794,164	3,028,302	977,009	941,503	6,740,978
1959	1,831,234	3,643,912	925,486	1,258,106	7,658,738
1960	2,060,419	4,159,424	741,557	1,033,686	7,995,086
1961	1,952,693	3,701,085	836,945	725,325	7,216,048
1962	2,960,265	3,363,019	1,148,886	1,176,768	8,648,938
1963	1,738,710	3,206,225	945,553	487,872	6,378,360
1964	1,505,686	2,328,045	1,315,944	343,631	5,493,306
1965	1,443,637	2,557,535	1,086,923	905,241	5,993,336
1966	1,451,598	2,392,220	958,737	538,891	5,341,446
1967	1,283,947	3,110,090	755,193	394,851	5,544,081
1968	1,231,179	3,069,935	649,731	186,288	5,137,133
1969	900,297	3,029,700	648,525	359,557	4,938,079
1970	704,455	3,716,915	1,230,380	326,027	5,977,777

*Includes iron, titanium, uranium, molybdenum and other metal deposits.
Note: Non-producing companies are not included since 1964.

Table 53. Canada, exploration diamond drilling, metal deposits, 1957-1970

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
		(footage)	
1957	1,175,526	4,046,336	5,221,862
1958	777,994	3,939,059	4,717,053
1959	786,701	4,485,109	5,271,810
1960	880,515	4,624,067	5,504,582
1961	993,099	4,387,051	5,380,150
1962	548,603	5,734,983	6,283,586
1963	1,184,977	3,836,262	5,021,239
1964	469,205	3,520,293	3,989,498
1965	685,704	3,861,537	4,547,241
1966	536,022	3,428,021	3,964,043
1967	305,657	3,684,833	3,990,490
1968	522,775	3,250,298	3,773,073
1969	443,936	3,518,138	3,962,074
1970	203,896	4,029,074	4,232,970

Note: Non-producing companies are not included since 1964.
See footnote Table 54.

Table 54. Canada, diamond drilling, other than for exploration, on metal deposits, by companies with own equipment and by drilling contractors, 1957-1970

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
		(footage)	
1957	1,721,535	512,009	2,233,544
1958	1,457,926	565,999	2,023,925
1959	1,603,618	783,310	2,386,928
1960	1,477,185	1,013,319	2,490,504
1961	1,261,262	574,636	1,835,898
1962	1,734,581	630,771	2,365,352
1963	1,273,714	83,407	1,357,121
1964	1,265,636	238,172	1,503,808
1965	1,292,479	153,616	1,446,095
1966	747,929	629,474	1,377,403
1967	611,755	941,836	1,553,591
1968	403,056	961,004	1,364,060
1969	287,247	688,758	976,005
1970	952,637	792,170	1,744,807

Note: Non-producing companies are not included since 1964.
The total footage drilled shown in Tables 53 and 54 equals the total footage drilled reported in Table 52.

Table 55. Canada, total contract diamond drilling operations*, 1959-1970

	Footage Drilled	Income from Drilling	Average No. of Employees	Total Salaries and Wages
Year	Feet	$ million	Number	$ million
1959	5,434,971	17.9	1,902	8.0
1960	5,521,211	17.1	1,912	8.0
1961	5,290,813	16.2	2,025	7.8
1962	5,549,733	17.9	1,926	8.0
1963	5,702,168	20.1	2,201	9.0
1964	6,479,096	23.7	2,401	11.2
1965	7,404,834	30.7	2,776	14.1
1966	7,466,264	33.7	2,887	15.1
1967	6,957,269	31.3	2,669	14.9
1968	7,615,175	38.7	2,985	18.8
1969	7,766,957	44.8	3,109	21.3
1970	7,627,493	53.2	3,207	24.3

*Includes contract diamond drilling in mining and in other industries.
[r]Revised.

Table 56. Canada, contract drilling for oil and gas, 1960-1970

	Footage Drilled				Gross Income from Drilling	Average No. of Employees	Total Salaries and Wages
	Rotary	Cable	Diamond	Total	$ million	Number	$ million
1960	13,538,783	231,748	–	13,770,531	75.2	4,860	23.2
1961	12,616,950	170,098	–	12,787,048	68.6	4,144	21.7
1962	12,459,736	252,467	–	12,712,203	62.2	3,800	20.8
1963	14,783,110	361,979	–	15,145,089	75.9	4,179	22.9
1964	14,803,776	229,726	6,230	15,039,732	81.9	4,158	25.2
1965	15,997,276	340,345	–	16,337,621	100.2	4,648	31.7
1966	13,394,413	210,104	–	13,604,517	95.8	4,428	33.9
1967	12,717,419	168,035	–	12,885,454	94.7	4,249	32.9
1968	13,300,766	230,443	–	13,531,209	109.5	4,434	36.9
1969	13,038,137	280,323	–	13,318,460	115.5	4,821	39.5
1970	11,500,845	165,042	–	11,665,887	112.6	4,267	37.9

– Nil.

Table 57. Canada, crude minerals transported by Canadian railways, 1970-1971

	1970	1971
	(000 short tons)	
Metallic minerals		
alumina and bauxite	3,255	3,235
copper ores and concentrates	2,018	2,182
iron ores and concentrates	49,382	47,840
iron pyrite	245	243
lead ores and concentrates	566	700
lead-zinc ores and concentrates	8	97
manganese ores	11	7
nickel-copper ores and concentrates	4,452	3,294
nickel ores and concentrates	1,169	1,125
zinc ores and concentrates	2,423	2,186
metallic ores and concentrates, n.e.s.	888	664
Total metallic minerals	64,417	61,573
Nonmetallic minerals		
abrasives, natural	215	131
asbestos	1,163	1,122
barite	71	47
clay	642	622
gravel	2,478	2,292
gypsum	4,041	3,912
limestone, agricultural	103	112
limestone, industrial	354	416
limestone, n.e.s.	3,575	3,181
nepheline syenite	466	482
phosphate rock	1,907[r]	2,058
potash (KCl)	5,714	5,982
refractory materials, n.e.s.	47	23
salt, rock	1,164	1,655
salt, n.e.s.	363	410
sand, industrial	1,236	1,236
sand, n.e.s.	1,560	1,284
silica	3	3
sodium carbonate	640	687
sodium sulphate	521	494
stone, building, rough	83	76
stone, n.e.s.	1,554	1,302
sulphur, liquid	1,392	1,234
sulphur, n.e.s.	1,734	1,835
nonmetallic minerals, n.e.s.	413	337
Total non metallic minerals	31,439[r]	30,933
Mineral fuels		
coal, anthracite	629	535
coal, bituminous	9,450	11,202
coal, lignite	1,312	845
coal, n.e.s.	19	17
natural gas and other crude bituminous substances	8	4
petroleum, crude	251	201
Total mineral fuels	11,669	12,804
Total crude minerals	107,525[r]	105,310
Total all revenue freight moved by Canadian railways	233,258	235,801
Per cent crude minerals of total all revenue freight	46.1	44.7

[r]Revised.
n.e.s. not elsewhere specified.

Table 58. Canada, crude minerals transported by Canadian railways, 1962-71

Year	Total Revenue Freight	Total Crude Minerals	Crude Minerals as a % of Total Revenue Freight
	(millions of short tons)		
1962	160.9	66.5	41.3
1963	170.4	69.3	40.7
1964	198.4	82.3	41.5
1965	205.2	89,2	43.5
1966	214.4	88.9	41.5
1967	209.5	89.5	42.7
1968	215.4	95.6	44.4
1969	208.3	90.3	43.4
1970	233.3	107.5	46.1
1971	235.8	105.3	44.7

Table 59. Canada, fabricated mineral products transported by canadian railways, 1970-71

	1970	1971
	(thousand short tons)	
Metallic mineral products		
Ferrous mineral products		
Ferroalloys	168	167
Pig iron	196	212
Ingots, blooms, billets, slabs of iron and steel	1,289	956
Other primary iron and steel	29	71
Castings and forgings, iron and steel	232	304
Bars and rods, steel	995	823
Plates, steel	545	416
Sheet and strip, steel	1,762	1,511
Structural shapes and sheet piling, iron and steel	645	554
Rails and railway track material	357	284
Pipes and tubes, iron and steel	731	710
Wire, iron or steel	53	52
Iron and steel scrap	1,855	1,808
Slags, drosses, etc.	319	246
Total ferrous mineral products	9,176	8,114
Nonferrous mineral products		
Aluminum paste, powder, pigs, ingots, shot	314	264
Aluminum and aluminum alloy fabricated material, nes	367	378
Copper matte and precipitates	64	10
Copper and alloys, in primary forms	690	603
Copper and alloys, n.e.s.	126	103
Lead and alloys	215	204
Nickel and nickel-copper matte	239	735
Nickel and alloys	151	165
Zinc and alloys	547	508
Other nonferrous base metals and alloys	25	8
Nonferrous metal scrap	187	286
Total nonferrous mineral products	2,925	3,264
Total metallic mineral products	12,101	11,378
Nonmetallic mineral products		
Natural stone basic products, chiefly structural	147	160
Bricks and tiles, clay	111	95
Fire brick and similar shapes	316	221
Dolomite and magnesite, calcined	90	78
Refractories, nes	59	52
Glass basic products	102	112
Asbestos and asbestos-cement basic products	37	34
Portland cement, standard	1,665	1,637
Concrete pipe	30	46
Cement and conctrete basic products, nes	292	288
Plaster	51	43
Gypsum wallboard and sheathing	72	82
Gypsum basic products, nes	1	1
Lime, hydrated and quick	671	608
Nonmetallic mineral basic products, nes	301	332
Fertilizers and fetilizer materials nes	1,692	2,110
Total nonmetallic mineral products	5,637	5,899
Mineral fuel products		
Gasoline	2,684	2,463
Aviation turbine fuel	46	135
Diesel fuel	3,505	3,370
Kerosene	12	14
Fuel oil, nes	1,213	1,141
Lubricating oils and greases	445	428
Petroleum coke	242	58
Coke, nes	1,810	1,606
Refined and manufactured gases, fuel type	2,774	2,964
Asphalts and road oils	291	240
Bituminous pressed or molded fabricated materials	20	17
Other petroleum and coal products	508	482
Total mineral fuel products	13,550	12,918
Total fabricated mineral products	31,288	30,195
Total revenue freight moved by Canadian railways	233,258	235,801
Fabricated mineral products as a percentage of total revenue freight	13.4[r]	12.8

[r]Revised; n.e.s. – not elsewhere specified.

Table 60. Canada, crude and fabricated minerals transported through the St. Lawrence Seaway, 1971-1972

	Montreal-Lake Ontario Section		Welland Canal Section	
	1971	1972	1971	1972
	(short tons)			
Crude minerals				
Bituminous coal	330,153	269,164	9,244,051	9,929,123
Iron ore	13,427,449	12,533,408	13,594,165	13,732,088
Aluminum ores and concentrates	128,311	101,080	128,311	101,080
Clay and bentonite	330,749	146,816	318,489	158,216
Gravel and sand	17,850	76	251,234	131,526
Stone, ground or crushed	24,881	5,789	940,864	1,094,612
Stone, rough	2,695	4,976	2,272	3,566
Petroleum, crude	42,907	86,641	–	–
Salt	510,122	889,117	1,187,845	1,623,310
Phosphate rock	73,437	102,934	–	–
Other crude minerals	768,171	658,719	680,973	572,915
Total crude minerals	15,656,725	14,798,720	26,348,204	27,346,436
Fabricated mineral products				
Coke	521,943	595,085	499,416	581,930
Gasoline	237,542	339,946	167,425	181,550
Fuel oil	2,534,339	3,229,339	1,227,627	1,377,832
Lubricating oils and greases	202,367	224,517	157,962	213,217
Other petroleum products	24,138	54,798	30,940	21,967
Tar, pitch, creosote	49,516	39,174	112,447	79,823
Pig iron	127,041	181,912	118,730	173,238
Iron and steel: bars, rods, slabs	269,519	286,084	255,208	249,670
Iron and steel: nails, wire	153,190	124,080	143,597	105,757
Iron and steel: other manufactured products	5,790,205	5,333,410	5,580,749	4,897,691
Scrap iron and steel	262,067	417,966	252,989	424,332
Cement	39,197	17,485	176,721	181,752
Total fabricated minerals	10,211,064	10,843,796	8,723,811	8,488,759
Total crude and fabricated minerals	25,867,789	25,642,516	35,072,015	35,835,195
Grand total all products	52,987,456	53,579,940	63,058,242	64,095,379
Per cent crude and fabricated minerals of grand total	48.8	47.9	55.6	55.9

– Nil.

Table 61. Canada, cargoes of crude minerals loaded and unloaded in coastwise shipping. 1971

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
	(short tons)							
Metallic minerals								
Copper ore and concentrates	52,092	4,500	4,085	60,677	56,592	–	4,085	60,677
Iron ore and concentrates	4,120,463	3,095,734	–	7,216,197	952,850	6,263,347	–	7,216,197
Manganese ore	95,475	–	–	95,475	25	95,450	–	95,475
Titanium ore	2,593,885	–	–	2,593,885	2,590,435	3,450	–	2,593,885
Zinc ore and concentrates	–	–	307	307	–	–	307	307
Ores and concentrates, n.e.s.	13,022	41	1,755	14,818	161	12,902	1,755	14,818
Iron and steel scrap	4,596	424	1,030	6,050	4,962	58	1,030	6,050
Nonferrous metal scrap	6,680	1,025	4	7,709	7,705	–	4	7,709
Slag, drosses, residues	85	14,218	13,856	28,159	85	14,218	13,856	28,159
Total metals	6,886,298	3,115,942	21,037	10,023,277	3,612,815	6,389,425	21,037	10,023,277
Nonmetallic minerals								
Asbestos	1,575	17	17	1,609	59	1,533	17	1,609
Barite	540	–	–	540	540	–	–	540
Clays, n.e.s.	1,599	2	494	2,095	1,549	52	494	2,095
Dolomite	463	41,748	–	42,211	16,307	25,904	–	42,211
Fluorspar	89,948	–	–	89,948	86,881	3,067	–	89,948
Gypsum	387,759	–	9,000	396,759	312,596	75,163	9,000	396,759
Limestone	10,800	1,748,130	396,443	2,155,373	10,800	1,748,130	396,443	2,155,373
Potash (KCl)	–	15,975	–	15,975	–	15,975	–	15,975
Salt	248,708	1,073,818	50,546	1,373,072	603,993	718,533	50,546	1,373,072
Sand and gravel	12,125	3	1,889,461	1,901,589	1,608	10,520	1,889,461	1,901,589
Stone, crushed	2	–	2,831	2,833	2	–	2,831	2,833
Stone, crude, n.e.s.	435	182,112	1,550	184,097	4,802	177,745	1,550	184,097
Sulphur	–	–	10,311	10,311	–	–	10,311	10,311
Crude nonmetallic minerals, n.e.s.	41	110	40	191	–	151	40	191
Total nonmetals	753,995	3,061,915	2,360,693	6,176,603	1,039,137	2,776,773	2,360,693	6,176,603
Mineral fuels								
Coal, bituminous	32,218	19,063	8	51,289	32,218	19,063	8	51,289
Total crude minerals	7,672,511	6,196,920	2,381,738	16,251,169	4,684,170	9,185,261	2,381,738	16,251,169
Grand total all commodities	21,384,532	24,606,516	14,776,713	60,767,761	27,559,200	18,438,348	14,770,213	60,767,761
Per cent crude minerals of grand total	35.9	25.2	16.1	26.7	17.0	49.8	16.1	26.7

n.e.s.–Not elsewhere specified; –Nil.

Table 62. Canada, Cargoes of crude minerals loaded and unloaded at Canadian ports in international shipping trade with foreign countries, 1970-1971

	1970		1971	
	Loaded	Unloaded	Loaded	Unloaded
	(short tons)			
Metallic minerals				
Alumina, bauxite ore	65,460	3,715,775	72,971	3,643,267
Copper ores and concentrates	513,128	32,063	693,160	30,592
Iron ore and concentrates	41,634,408	2,733,335	35,892,296	1,664,124
Lead ore and concentrates	184,043	12,347	162,691	12,851
Manganese ore	188,444	227,182	121,728	228,260
Nickel-copper ore and concentrates	177,758	76,831	117,418	84,342
Titanium ore	133,135	10,555	287,714	15,694
Zinc ore and concentrates	1,005,368	7,662	968,424	7,366
Ores and concentrates, n.e.s.	136,491	83,030	94,096	87,028
Iron and steel scrap	306,014	493	111,035	4,357
Nonferrous metal scrap	57,756	2,918	8,683	4,411
Slags, drosses, residues	721,832	8,709	783,291	15,207
Total metals	45,123,837	6,910,900	39,313,507	5,797,499
Nonmetallic minerals				
Asbestos	906,064	156,448	555,206	172,135
Barite	93,591	37	69,555	10,122
Bentonite	304	184,557	38,247	161,089
China clay	–	55,305	–	28,732
Clays, n.e.s.	2,792	46,728	1,080	46,002
Dolomite	945,152	31,020	877,476	–
Fluorspar	38,549	120,903	52,252	294,941
Gypsum	4,941,992	38,522	5,019,161	71,000
Limestone	1,485,044	1,690,767	1,465,412	1,693,771
Phosphate rock	–	829,636	122	1,075,376
Potash (KCl)	1,207,374	21,674	2,217,641	62,853
Salt	1,422,012	613,127	1,372,512	644,379
Sand and gravel	59,087	683,581	44,092	910,500
Stone, crushed	–	7	36	24,719
Stone, crude, n.e.s.	116,668	13,943	54,018	16,559
Sulphur	1,364,923	44,925	1,311,683	24,127
Crude nonmetallic minerals, n.e.s.	66,164	10,633	66,165	21,967
Total nonmetals	12,649,716	4,541,813	13,144,658	5,258,272
Mineral fuels				
Coal, bituminous	3,717,180	18,135,388	6,088,427	17,186,827
Coal, n.e.s.	–	378,155	–	428,349
Natural gas	–	–	–	7,665
Petroleum, crude	72,554	7,304,974	145,983	12,640,074
Total fuels	3,789,734	25,818,517	6,234,410	30,262,915
Total crude minerals	61,563,287	37,271,230	58,692,575	41,318,686
Grand total, all commodities	105,608,960	58,781,126	105,697,016	60,857,110
Per cent crude minerals of grand total	58.3	63.4	55.5	67.9

n.e.s. Not elsewhere specified; –Nil.

Table 63. Canada, cargoes of fabricated mineral products loaded and unloaded at Canadian ports in international shipping trade with foreign countries, 1970-1971

	1970		1971	
	Loaded	Unloaded	Loaded	Unloaded
	(short tons)			
Metallic products				
aluminum	547,700	7,379	500,455	8,803
copper and alloys	193,531	2,292	79,840	7,129
ferroalloys	58,713	13,265	16,837	49,733
iron and steel, primary	133,116	14,058	116,943	61,192
iron, pig	693,356	13,460	495,566	17
iron and steel, other				
bars and rods	158,447	176,369	31,744	204,550
castings and forgings	29,944	13,967	29,075	26,457
pipe and tubes	14,536	97,437	9,357	183,972
plate and sheet	279,406	249,927	207,219	510,834
rails and track material	4,107	5,478	30,975	6,718
structural shapes	114,553	219,563	52,081	461,419
wire	6,125	48,351	2,984	25,031
lead and alloys	87,054	6,312	54,072	283
nickel and alloys	43,946	12,241	19,052	13,353
zinc and alloys	204,152	686	104,823	365
nonferrous metals, n.e.s.	13,172	6,553	11,812	10,339
metal fabricated basic products, n.e.s.	32,317	102,732	20,843	79,847
Total metals	2,614,175	990,070	1,783,678	1,650,042
Nonmetallic products				
asbestos basic products	4,754	2,974	7,822	176
building brick, clay	1,942	2,051	1,591	1,760
bricks and tiles, n.e.s.	25,769	30,098	22,127	22,777
cement	748,484	27,163	915,182	24,339
cement basic products	4,426	723	1,916	1,296
drain tiles and pipes	–	11	–	565
glass basic products	4,733	62,924	2,969	38,469
lime	4,268	279	4,164	713
nonmetallic mineral basic products	25,750	16,879	52,997	13,628
fertilizers, n.e.s.	182,366	89,198	114,568	123,220
Total nonmetals	1,002,492	232,300	1,123,336	226,943
Mineral fuel products				
asphalts, road oils	36,301	56,424	742	28,688
coal tar, pitch	49,748	67,447	27,651	103,920
coke	264,874	510,452	153,616	807,395
fuel oil	1,181,546	8,718,476	2,097,706	6,928,559
gasoline	34,968	627,242	40,288	546,093
lubricating oil and greases	1,388	37,156	1,950	49,980
petroleum and coal products, n.e.s.	287,306	137,899	306,978	170,518
Total fuels	1,856,131	10,155,096	2,628,931	8,635,153
Total fabricated minerals products	5,472,798	11,377,466	5,535,945	10,512,138
Grand total, all commodities	105,608,960	58,781,126	105,697,016	60,857,110
Per cent fabricated mineral products of grand total	5.2	19.4	5.2	17.4

n.e.s. Not elsewhere specified; –Nil.

Table 64. Canada, taxes[1] paid to federal, provincial and municipal government by important divisions of mineral industry, 1969 and 1970, $000

	1969				1970			
	Federal Income Tax[2]	Provincial Tax[3]	Municipal Tax[4]	Total	Federal Income Tax[2]	Provincial Tax[3]	Municipal Tax[4]	Total
Metal mining								
Auriferous quartz	2,690	1,286	923	4,899	925	1,089	1,093	3,107
Copper-gold-silver mining, smelting and refining	26,400	25,398	3,414	55,212	26,994	31,630	4,365	62,989
Silver-lead-zinc mining, smelting and refining	10,481	6,053	4,129	20,663	11,418	4,482	1,134	17,034
Nickel-copper mining, smelting and refining	20,026	15,680	3,752	39,458	13,130	11,837	7,514	32,481
Iron	3,163	9,358	6,115	18,636	5,687	9,795	6,140	21,622
Miscellaneous metal mining	498	1,635	961	3,094	5,146	4,035	1,925	11,106
Total metal mining	63,258	59,410	19,294	141,962	63,300	62,868	22,171	148,339
Nonmetal mining								
Asbestos	14,313	8,839	2,901	26,053	11,191	8,031	3,009	22,231
Feldspar, quartz and nepheline syenite mining	67	175	42	284	75	50	76	201
Gypsum	647	327	397	1,371	437	320	388	1,145
Peat	95	73	124	292	128	97	127	352
Salt	–	1,558	355	1,913	–	1,708	387	2,095
Talc and soapstone mining	3	20	7	30	31	21	7	59
Stone quarries	1,423	567	554	2,544	866	456	552	1,874
Sand and gravel pits	1,122	706	421	2,249	875	663	578	2,116
Miscellaneous nonmetal mining	1,965	3,391	2,598	7,954	3,527	793	337	4,657
Total nonmetal mining	19,635	15,656	7,399	42,690	17,130	12,139	5,461	34,730
Total of divisions covered	82,893	75,066	26,693	184,652	80,430	75,007	27,632	183,069

[1] Taxes reported are actual payments made within the calendar years, and do not reflect tax assessments.
[2] Includes tax on non-operating revenue.
[3] Includes mining tax, corporation income tax, acreage taxes and royalties.
[4] Taxes based on property valuation.
–Nil.

Table 65. Canada, taxes* paid by six important divisions of the mineral industry, 1964-70, $ million

	1964	1965	1966	1967	1968	1969	1970
Auriferous quartz mining	5.2	4.4	5.2	4.9	4.2	4.9	3.1
Copper-gold-silver mining, smelting and refining	26.0	34.9	34.3	49.3	52.1	55.2	63.0
Silver-lead-zinc mining, smelting and refining	26.5	27.9	22.9	18.7	15.5	20.7	17.0
Nickel-copper mining, smelting and refining	47.8	77.7	70.7	44.9	50.2	39.5	32.5
Iron mining	6.1	11.6	15.0	13.0	17.2	18.6	21.6
Asbestos mining	20.3	22.5	26.3	26.2	19.9	26.0	22.2
Total	131.9	179.0	174.4	157.0	159.1	164.9	159.4

*See footnotes Table 64.

Table 66. Canada, provision for income taxes, current and future period, mining and mineral manufacturing industries, 1969-71

	1969			1970			1971		
	Current	Future	Total	Current	Future	Total	Current	Future	Total
	$ millions								
Mining									
Metal mining	100	39	139	165	47	212	72	30	102
Mineral fuels	25	22	47	49	28	77	39	30	69
Other mining	30	3	33	27	12	39	23	13	36
Total mining	155	64	219	241	87	328	134	73	207
Mineral manufacturing									
Primary metals	104	−9	95	82	5	87	65	26	91
Nonmetallic mineral products	39	8	47	31	−2	29	52	2	54
Petroleum and coal products	54	37	91	99	26	125	123	35	158
Total mineral manufacturing	197	36	233	212	29	241	240	63	303
Total, mining and mineral manufacturing	352	100	452	453	116	569	374	136	510
Total all industries*	2,134	256	2,390	1,932	275	2,207	2,161	264	2,425
Per cent mining and mineral manufacturing of total, all industries	16.5	39.1	18.9	23.4	42.2	25.8	17.3	51.5	21.0

*Excludes agriculture, fishing, trapping and construction.

Table 67. Canada, capital and repair expenditures in mining[1] and mineral manufacturing industries, 1971, 1972 and 1973

	1971			1972p			1973f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ millions)				
Mining Industry									
Metal mines									
Gold	11.8	4.4	16.2	15.6	4.2	19.8	13.4	4.6	18.0
Silver lead zinc	25.9	16.9	42.8	24.8	13.8	38.6	30.3	11.2	41.5
Iron	252.9	96.5	349.4	270.5	93.9	364.4	212.4	113.9	326.3
Other metal mines	540.0	162.0	702.0	344.8	137.7	482.5	260.1	154.3	414.4
Total metal mines	830.6	279.8	1,110.4	655.7	249.6	905.3	516.2	284.0	800.2
Nonmetal mines									
Quarries and sandpits	12.2	18.2	30.4	14.4	15.9	30.3	20.7	15.6	36.3
Other nonmetal mines[2]	178.0	96.8	274.8	113.5	101.2	214.7	114.2	99.9	214.1
Total nonmetal mines	190.2	115.0	305.2	127.9	117.1	245.0	134.9	115.5	250.4
Mineral fuels									
Petroleum and gas[3]	740.7	131.4	872.1	809.0	137.4	946.4	919.2	162.0	1,081.2
Total mining industries	1,761.5	526.2	2,287.7	1,592.6	504.1	2,096.7	1,570.3	561.5	2,131.8
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	201.6	197.0	398.6	193.2	207.8	401.0	219.0	230.4	449.4
Steel pipe and tube mills	11.0	11.6	22.6	15.1	12.7	27.8	18.4	14.9	33.3
Iron foundries	11.6	11.9	23.5	11.4	13.1	24.5	18.2	12.2	30.4
Smelting and refining	163.3	137.0	300.3	132.0	125.7	257.7	77.4	129.6	207.0
Aluminum, rolling, casting and extruding	7.4	6.6	14.0	8.3	6.2	14.5	14.2	6.6	20.8
Copper and alloy rolling casting and extruding	2.2	5.2	7.4	3.7	5.0	8.7	3.1	5.1	8.2
Other primary metal industries	4.3	2.6	6.9	4.0	3.1	7.1	4.8	3.1	7.9
Total primary metal industries	401.4	371.9	773.3	367.7	373.6	741.3	355.1	401.9	757.0

Table 67. (concl'd)

	1971			1972^p			1973^f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ millions)				
Nonmetallic mineral products									
Cement	13.7	17.2	30.9	46.5	19.7	66.2	59.7	20.9	80.6
Lime	4.0	1.7	5.7	1.9	2.0	3.9	2.0	2.0	4.0
Gypsum products	1.6	2.5	4.1	3.8	1.9	5.7	5.3	2.1	7.4
Concrete products and ready mix	32.4	38.6	71.0	43.5	43.1	86.6	48.4	42.9	91.3
Clay products	4.0	5.4	9.4	3.1	3.0	6.1	6.4	3.0	9.4
Refractories	1.4	1.9	3.3	1.2	1.8	3.0	2.0	1.9	3.9
Asbestos	2.2	2.5	4.7	2.5	3.5	6.0	3.0	3.6	6.6
Glass and glass products	16.4	9.1	25.5	16.9	5.2	22.1	14.7	4.9	19.6
Abrasives	2.7	4.6	7.3	2.3	4.8	7.1	3.0	5.0	8.0
Other nonmetallic mineral products	1.9	3.9	5.8	4.1	5.4	9.5	8.8	7.0	15.8
Total nonmetallic mineral products	80.3	87.4	167.7	125.8	90.4	216.2	153.3	93.3	246.6
Petroleum and coal products	231.4	61.1	292.5	231.5	62.9	294.4	313.9	68.4	382.3
Total minerals manufacturing industries	713.1	520.4	1,233.5	725.0	526.9	1,251.9	822.3	563.6	1,385.9
Total mining and mineral manufacturing industries	2,474.6	1,046.6	3,521.2	2,317.6	1,031.0	3,348.6	2,392.6	1,125.1	3,517.7

[1] Does not include cement, lime and clay products (domestic clay) manufacturing, smelting and refining.
[2] Includes coal mines, asbestos, gypsum, salt and miscellaneous nonmetals.
[3] The total of capital expenditures shown under "petroleum and gas" is equal to the total capital expenditure under the column entitled "petroleum and natural gas extraction" and under the column "natural gas processing plants" of Table 70.
[p] Preliminary; [f] Forecast intentions.

Table 68. Canada, capital and repair expenditures in the mining industry[1], 1963-1973

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972p	1973f
						($ million)					
Metal mines											
Capital											
Construction	118.3	147.0	121.4	209.9	238.1	264.8	295.1	335.6	590.8	392.9	279.5
Machinery	71.6	92.8	79.2	138.5	131.3	105.2	98.2	150.3	239.8	262.8	236.7
Total	189.9	239.8	200.6	348.4	369.4	370.0	393.3	485.9	830.6	655.7	516.2
Repair											
Construction	15.8	17.7	21.9	25.1	33.4	47.9	35.7	36.6	38.9	31.3	33.4
Machinery	76.3	84.4	100.5	115.9	116.6	152.2	160.9	220.2	240.9	218.3	250.6
Total	92.1	102.1	122.4	141.0	150.0	200.1	196.6	256.8	279.8	249.6	284.0
Total capital and repair	282.0	341.9	323.0	489.4	519.4	570.1	589.9	742.7	1,110.4	905.3	800.2
Nonmetal mines											
Capital											
Construction	18.7	36.7	58.1	106.7	121.1	110.2	128.1	107.9	84.6	47.8	52.2
Machinery	40.8	45.0	34.8	68.9	85.4	128.4	113.9	115.9	105.6	80.1	82.7
Total	59.5	81.7	92.9	175.6	206.5	238.6	242.0	223.8	190.2	127.9	134.9
Repair											
Construction	3.6	3.2	3.7	3.4	4.5	4.3	10.4	7.1	7.9	6.6	5.4
Machinery	31.5	37.9	47.2	49.4	57.0	57.5	64.7	99.9	107.1	110.5	110.1
Total	35.1	41.1	50.9	52.8	61.5	61.8	75.1	107.0	115.0	117.1	115.5
Total capital and repair	94.6	122.8	143.8	228.4	268.0	300.4	317.1	330.8	305.2	245.0	250.4
Mineral fuels											
Capital											
Construction	234.3	270.6	419.2	450.0	403.0	407.4	465.3	552.6	639.4	731.6	833.3
Machinery	37.9	40.5	22.1	55.8	71.8	58.0	76.6	86.2	101.3	77.4	85.9
Total	272.2	311.1	441.3	505.8	474.8	465.4	541.9	638.8	740.7	809.0	919.2
Repair											
Construction	15.7	23.6	25.4	28.6	34.2	56.3	73.7	93.5	102.7	104.7	121.8
Machinery	13.9	10.8	24.0	21.3	14.7	19.2	19.0	22.5	28.7	32.7	40.2
Total	29.6	34.4	49.4r	49.9	48.9	75.5	92.7	116.0	131.4	137.4	162.0
Total capital and repair	301.8	345.5	490.7	555.7	523.7	540.9	634.6	754.8	872.1	946.4	1,081.2

Table 68 (concl'd)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972^{p}	1973^{f}
						($ million)					
Total mining											
Capital											
Construction	371.3	454.3	598.7	766.6	762.2	782.4	888.5	996.1	1,314.8	1,172.3	1,165.0
Machinery	150.3	178.3	136.1	263.2	288.5	291.6	288.7	352.4	446.7	420.3	405.3
Total	521.6	632.6	734.8	1,029.8	1,050.7	1,074.0	1,177.2	1,348.5	1,761.5	1,592.6	1,570.3
Repair											
Construction	35.1	44.5	51.0	57.1	72.1	108.5	119.8	137.2	149.5	142.6	160.6
Machinery	121.7	133.1	171.7	186.6	188.3	228.9	244.6	342.6	376.7	361.5	400.9
Total	156.8	177.6	222.7	243.7	260.4	337.4	364.4	479.8	526.2	504.1	561.5
Total capital and repair	678.4	810.2	957.5	1,273.5	1,311.1	1,411.4	1,541.6	1,828.3	2,287.7	2,096.7	2,131.8

[1]Does not include cement, lime and clay products (domestic clays) manufacturing, smelting and refining.
[2]Includes coal mines, asbestos, gypsum, salt, miscellaneous nonmetals, quarrying and sand pits.
[p]Preliminary estimates of intentions; [f]Forecast intentions; [r]Revised.

Table 69. Canada, capital and repair expenditures in the mineral manufacturing industries[1], 1963-1973

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972^{p}	1973^{f}
						($ million)					
Primary metal industries[2]											
Capital											
Construction	44.4	58.4	61.6	85.2	82.0	77.5	71.5	114.0	89.0	80.4	60.1
Machinery	136.8	214.4	202.9	300.7	202.8	157.9	221.4	311.2	312.4	287.3	295.0
Total	181.2	272.8	264.5	385.9	284.8	235.4	292.9	425.2	401.4	367.7	355.1
Repair											
Construction	16.6	18.0	18.5	21.8	24.9	27.7	22.6	28.6	28.4	29.9	32.4
Machinery	166.1	194.4	215.0	253.4	258.1	281.4	267.9	324.6	343.5	343.7	369.5
Total	182.7	212.4	233.5	275.2	283.0	309.1	290.5	353.2	371.9	373.6	401.9
Total capital and repair	363.9	485.2	498.0	661.1	567.8	544.5	583.4	778.4	773.3	741.3	757.0

(Continued on page 586)

Table 69. (concl'd)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972^p	1973^f
						($ million)					
Nonmetallic mineral products[3]											
Capital											
Construction	13.8	20.1	30.0	50.9	39.5	19.6	37.1	30.7	21.8	27.5	28.1
Machinery	38.9	61.9	78.3	108.6	80.3	66.5	84.0	104.3	58.5	98.3	125.2
Total	52.7	82.0	108.3	159.5	119.8	86.1	121.1	135.0	80.3	125.8	153.3
Repair											
Construction	5.5	5.4	6.4	7.2	9.3	7.2	7.2	5.4	7.0	8.2	8.7
Machinery	52.8	58.3	66.1	72.1	63.9	73.8	72.1	77.1	80.4	82.2	84.6
Total	58.3	63.7	72.5	79.3	73.2	81.0	79.3	82.5	87.4	90.4	93.3
Total capital and repair	111.0	145.7	180.8	238.8	193.0	167.1	200.4	217.5	167.7	216.2	246.6
Petroleum and coal products											
Capital											
Construction	38.0	20.4	30.3	55.5	78.8	99.0	116.9	213.7	211.3	211.8	301.2
Machinery	8.6	4.3	10.3	9.6	21.4	28.8	12.9	17.4	20.1	19.7	12.7
Total	46.6	24.7	40.6	65.1	100.2	127.8	129.8	231.1	231.4	231.5	313.9
Repair											
Construction	30.0	32.3	29.5	32.6	36.0	46.6	52.1	51.0	51.3	50.9	54.5
Machinery	5.2	5.9	7.0	9.1	10.2	8.6	6.8	9.2	9.8	12.0	13.9
Total	35.2	38.2	36.5	41.7	46.2	55.2	58.9	60.2	61.1	62.9	68.4
Total capital and repair	81.8	62.9	77.1	106.8	146.4	183.0	188.7	291.3	292.5	294.4	382.3
Total mineral manufacturing industries											
Capital											
Construction	96.2	98.9	121.9	191.6	200.3	196.1	225.5	358.4	322.1	319.7	389.4
Machinery	184.3	280.6	291.5	418.9	304.5	253.2	318.3	432.9	391.0	405.3	432.9
Total	280.5	379.5	413.4	610.5	504.8	449.3	543.8	791.3	713.1	725.0	822.3
Repair											
Construction	52.1	55.7	54.4	61.6	70.2	81.5	81.9	85.0	86.7	89.0	95.6
Machinery	224.1	258.6	288.1	334.6	332.2	363.8	346.8	410.9	433.7	437.9	468.0
Total	276.2	314.3	342.5	396.2	402.4	445.3	428.7	495.9	520.4	526.9	563.6
Total capital and repair	556.7	693.8	755.9	1,006.7	907.2	894.6	972.5	1,287.2	1,233.5	1,251.9	1,385.9

[1]Industry groups are the same as in Table 28.
[2]Includes smelting and refining.
[3]Includes cement, lime, and clay products manufacturing.
[p]Preliminary estimates of intentions; [f]Forecast intentions.

Table 70. Canada, capital expenditures in the petroleum and natural gas and allied industries[1], 1962-1973

	Petroleum and natural gas extraction[2]	Transportation including rail, water and pipelines	Marketing (chiefly outlets of oil companies)	Natural gas distribution	Petroleum refining including lubricants	Natural gas processing plants	Total Capital Expenditures
				($ million)			
1962	268.9	72.2	47.7	69.3	64.8	21.9	544.8
1963	297.1	107.9	53.0	84.1	44.2	38.6	624.9
1964	336.7	164.0	48.3	68.3	23.9	40.6	681.8
1965	381.0	112.1	55.2	72.5	39.8	41.5	702.1
1966	453.5	154.0	64.0	92.3	64.8	50.1	878.7
1967	385.1	204.9	86.8	76.4	99.6	89.7	942.5
1968	374.3	247.9	87.6	117.4	127.6	91.1	1,045.9
1969	438.1	220.6	103.6	117.0	128.9	103.8	1,112.0
1970	449.3	246.5[r]	100.0	100.4	229.8	189.5	1,315.5
1971	489.6	352.0	99.2	115.2	227.0	251.1	1,534.1
1972[p]	668.2	460.2	119.0	137.0	228.1	140.8	1,753.3
1973[f]	777.3	405.0	134.2	145.1	311.5	141.9	1,915.0

[1]The petroleum and natural gas industries in this table include all companies engaged, in whole or in part, in oil and gas activities.
[2]Includes capital expenditures by oil and gas drilling contractors back to 1961. Does not include expenditures for geological and geophysical operations. See also footnote 3 of Table 67.
[p]Preliminary; [f]Forecast intentions; [r]Revised.

Table 71. Canada, financial statistics of corporations in the mining industry*,

	Corporations		Assets	
	Number	%	$ million	%
Metal mines				
Reportaing corporations				
50 per cent and over non-resident	50	23	3,459	52
Under 50 per cent non-resident	135	62	3,112	47
Government business enterprise	1	--	86	1
Other corporations	34	15	3	--
Total, all corporations	220	100	6,660	100
Mineral fuels				
Reporting corporations				
50 per cent and over non-resident	233	30	4,519	79
Under 50 per cent non-resident	189	24	1,180	21
Government business enterprise	1	--	..	..
Other corporations	362	46	..	..
Total, all corporations	785	100	5,728	100
Other mining (including mining services)				
Reporting corporations				
50 per cent and over non-resident	188	7	1,548	56
Under 50 per cent non-resident	923	33	1,103	39
Government business enterprise	2	--	..	..
Other corporations	1,622	60	..	..
Total, all corporations	2,735	100	2,815	100
Total mining				
Reporting corporations				
50 per cent and over non-resident	471	13	9,526	63
Under 50 per cent non-resident	1,247	32	5,395	35
Government business enterprise	4	--	97	1
Other corporations	2,018	55	185	1
Total, all corporations	3,740	100	15,203	100

*Classification of the industry is the same as in Table 27.
Note: Footnotes for Table 72 apply to this Table.
– Nil.
.. Not available.
-- Amount too small to be expressed.

by degree of non-resident ownership, 1970

Equity		Sales		Profits		Taxable Income	
$ million	%	$ million	%	$ million	%	$ million	%
2,001	47	1,813	58	480	55	125.2	57.5
2,228	52	1,283	41	395	45	92.6	42.5
49	1	21	1	-2	--	} .1	--
1	--	1	--	--	--		
4,279	100	3,118	100	873	100	217.9	100.0
2,986	80	1,360	90	215	78	58.3	94.8
772	20	142	9	66	24	1.9	3.0
..	..	..	..	..	..	} 1.4	2.2
..	..	..	..	-4	-2		
3,768	100	1,514	100	277	100	61.6	100.0
842	51	644	60	87	82	40.6	66.4
732	44	350	33	26	25	15.7	25.7
..	..	..	..	..	..	} 4.9	7.9
..	..	..	..	..	..		
1,670	100	1,073	100	106	100	61.2	100.0
5,829	60	3,817	67	782	62	224.1	65.8
3,732	38	1,775	31	487	39	110.2	32.4
57	1	24	--	-2	--	} 6.4	1.8
99	1	89	2	-11	-1		
9,717	100	5,705	100	1,256	100	340.7	100.0

Table 72. Canada, financial statistics of corporations in the mineral manufacturing industries*

	Corporations[1]		Assets[4]	
	Number	%	$ million	%
Primary metal products				
Reporting corporations[1]				
50% and over non-resident	68	16	2,408	52
under 50% non-resident	144	33	2,030	44
Government business enterprises[2]	3	1	199	4
Other[3]	223	50	20	- -
Total all corporations	438	100	4,657	100
Nonmetallic mineral products				
Reporting corporations[1]				
50% and over non-resident	80	8	884	47
under 50% non-resident	371	38	933	49
Government business enterprises[2]	2	- -	. .	. .
Other[3]	515	54	. .	. .
Total all corporations	968	100	1,884	100
Petroleum and coal products				
Reporting corporations[1]				
50% and over non-resident	26	47	5,828	100
under 50% non-resident	12	21	22	- -
Government business enterprises[2]	- -	—	—	—
Other[3]	18	32	3	- -
Total all corporations	56	100	5,853	100
Total mineral manufacturing industries				
Reporting companies[1]				
50% and over non-resident	174	11.9	9,120	73.6
under 50% non-resident	527	36.1	2,985	24.1
Government business enterprises[2]	5	.3	. .	. .
Other[3]	756	51.7	. .	. .
Total all corporations	1,462	100.0	12,394	100.0

*Classification of industries is the same as in Table 28.

[1] Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50% or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership.

[2] Non-taxable federal and provincial Crown Corporations and municipally owned corporations.

[3] Corporations exempt from reporting under the Corporations and Labour Unions Returns Act. These include corporations reporting under other acts, small companies and corporations and non-profit organizations.

[4] Assets – Included are cash, marketable securities, accounts, receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation.

[5] Equity – This represents the shareholders interest in the net assets of the corporation and includes the total amount of all issued and paid up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus.

[6] Sales – For non-financial corporations, sales are gross revenues from non-financial operations. For financial corporations sales include income from financial as well as non-financial sources.

[7] Profits – The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends.

[8] Taxable Income – The figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.

Symbols: — nil; . . not available; - - amount too small to be expressed.

by degree of non-resident ownership, 1970

Equity[5]		Sales[6]		Profits[7]		Taxable Income[8]	
$ million	%	$ million	%	$ million	%	$ million	%
1,156	52	1,667	48	122	44	56.3	33.0
979	44	1,590	46	150	54	112.5	66.0
94	4	171	5	6	2	} 1.6	1.0
8	--	40	1	1	–		
2,237	100	3,468	100	279	100	1,704	100.0
477	54	644	44	32	42	55.0	74.2
381	32	756	51	43	56	16.1	21.7
..	..	..	..	..	..	} 3.0	4.1
..	..	..	..	..	..		
888	100	1,479	100	77	100	741	100.0
3,602	100	4,081	99	447	99	138.7	98.7
12	--	51	1	5	1	1.7	1.2
–	–	–	–	–	–	} .1	.1
1	--	3	--	1	--		
3,615	100	4,135	100	453	100	1,405	100.0
5,235	77.7	6,392	70.4	601	74.3	250.0	64.9
1,372	20.4	2,397	26.4	198	24.5	130.0	33.9
..	..	..	..	..	..	} 4.7	1.2
..	..	..	..	..	..		
6,740	100.0	9,082	100.0	809	100.0	385.0	100.0

Table 73. Canada, financial statistics of corporations in non-financial industries,

		Agriculture, Forestry, Fishing and Trapping		Mining		Manufacturing	
		1969	1970	1969	1970	1969	1970
Number of corporations	**number**						
Foreign control	number	83	88	473	471	2,320	2,380
Canadian control	number	1,222	1,414	1,208	1,247	6,916	7,207
Other corporations	number	4,489	5,118	2,029	2,022	11,849	12,425
Total corporations	number	5,794	6,620	3,710	3,740	21,085	22,012
Assets	**$ millions**						
Foreign control	$ millions	209	202	9,039	9,526	25,784	27,878
Canadian control	$ millions	701	810	4,597	5,395	17,232	17,798
Other corporations	$ millions	430	493	273	282	1,557	1,611
Total corporations	$ millions	1,340	1,505	13,909	15,203	44,573	47,287
Equity							
Foreign control	$ millions	143	144	5,462	5,829	13,687	14,549
Canadian control	$ millions	238	268	3,246	3,732	8,046	8,107
Other corporations	$ millions	107	121	151	156	550	579
Total corporations	$ millions	488	533	8,859	9,717	22,283	23,235
Sales							
Foreign control	$ millions	85	85	3,202	3,817	29,297	29,635
Canadian control	$ millions	530	636	1,595	1,775	21,051	21,598
Other corporations	$ millions	367	416	103	113	2,220	2,210
Total corporations	$ millions	982	1,137	4,900	5,705	52,568	53,443
Profits							
Foreign control	$ millions	11	15	672	782	2,303	1,780
Canadian control	$ millions	30	26	405	487	1,280	1,052
Other corporations	$ millions	13	10	-14	-13	48	50
Total corporations	$ millions	54	51	1,063	1,256	3,631	2,882
Taxable income							
Foreign control	$ millions	1.4	3.7	64.9	191.6	1,563.3	1,206.0
Canadian control	$ millions	16.0	16.3	62.3	68.5	969.6	747.9
Other corporations	$ millions	5.7	7.4	-9.4	-7.9	31.9	34.0
Total corporations	$ millions	23.1	27.4	117.8	252.2	2,564.8	1,987.9

by major industry group and by control, 1969 and 1970

Construction		Transportation, Communication and Other Utilities		Trade		Services		Total	
1969	1970	1969	1970	1969	1970	1969	1970	1969	1970
153	177	243	239	1,721	1,804	450	493	5,443	5,652
4,357	4,348	1,539	1,593	12,156	12,977	3,485	3,768	30,883	32,554
14,693	15,400	6,351	6,981	39,614	42,265	22,825	24,618	101,850	108,829
19,203	19,925	8,133	8,813	53,491	57,046	26,760	28,879	138,176	147,035
700	976	1,825	1,883	4,766	5,128	1,330	1,360	43,653	46,953
4,353	4,491	13,149	14,194	10,599	11,335	2,932	3,251	53,563	57,274
1,058	1,097	21,772	23,146	4,105	4,231	1,453	1,543	30,648	32,403
6,111	6,564	36,746	39,223	19,470	20,694	5,715	6,154	127,864	136,630
167	186	656	655	1,790	1,957	555	536	22,460	23,856
1,021	1,049	5,640	6,093	4,046	4,483	1,019	1,092	23,256	24,824
343	356	5,775	5,891	1,097	1,229	460	485	8,483	8,817
1,531	1,591	12,071	12,639	6,933	7,669	2,034	2,113	54,199	57,497
1,051	1,338	907	951	9,698	10,574	896	1,084	45,136	47,484
5,732	5,946	5,100	5,826	26,405	28,157	2,434	2,653	62,847	66,591
1,954	2,008	4,467	5,039	7,494	8,510	1,865	2,036	18,470	20,332
8,737	9,292	10,474	11,816	43,597	47,241	5,195	5,773	126,453	134,407
51	29	94	129	324	328	97	114	3,552	3,177
175	138	739	830	643	645	143	136	3,415	3,314
71	60	108	134	530	676	94	88	850	1,005
297	227	941	1,093	1,497	1,649	334	338	7,817	7,496
41.8	33.7	105.1	121.7	286.4	288.3	73.5	72.4	2,136.4	1,917.3
102.0	82.2	217.2	431.8	525.7	556.8	90.9	93.4	1,983.7	1,996.9
58.0	58.0	16.7	25.1	148.4	147.8	76.1	86.1	327.4	350.5
201.8	173.9	339.0	578.6	960.5	992.9	240.5	251.9	4,447.5	4,264.7

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